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BIOMETRIKA

A JOURNAL FOR THE STATISTICAL STUDY OF BIOLOGICAL PROBLEMS

FOUNDED BY
W. F. R. WELDON, FRANCIS GALTON AND KARL PEARSON

EDITED
IN CONSULTATION WITH FRANCIS GALTON
AND IN COLLABORATION WITH

C. B. DAVENPORT
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RAYMOND PEARL

BY
KARL PEARSON

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CONTENTS.

Memoirs.

PAGE

I. The Probable Error of a Mean. By "STUDENT" 1

II. Split-Hand and Split-Foot Deformities, their Types, Origin and Transmission. By THOMAS LEWIS, M.D., D.Sc., and DENNIS EMBLETON 26

III. On the Generalised Probable Error in Multiple Normal Correlation. By KARL PEARSON, F.R.S., and ALICE LEE, Sc.D. . . . 59

IV. On the Inheritance of the Deformity known as Split-Foot or Lobster-Claw. By KARL PEARSON, F.R.S. 69

V. On a Determinantal Theory of Inheritance, from Notes and Suggestions by the late W. F. R. Weldon. By KARL PEARSON, F.R.S. . . 80

VI. Pigmentation Survey of School Children in Scotland.

(*a*) Committee and Grants 129

(*b*) Report. By J. F. TOCHER 130

VII. Variation, Development and Growth in *Holothuria floridana,* Pourtalès. By CHARLES LINCOLN EDWARDS 236

VIII. Probable Error of a Correlation Coefficient. By "STUDENT" . 302

IX. Zur Frage vom viergliederigen Tarsus der *Blattidae* und der Regeneration der Füsse derselben. Von TH. S. SCHTSCHERBAKOW . 311

X. Some Statistical Observations on Termites, mainly based on the work of the late Mr G. D. Haviland. By ERNEST WARREN, D.Sc. . 329

XI. Note on the Skin-Colour of the Crosses between Negro and White. By KARL PEARSON, F.R.S. 348

XII. Ueber die Längenvariation der Coniferennadeln. Von A. HEYER . 354

XIII. Statistical Study of Anti-typhoid Inoculation. By G. D. MAYNARD 366

PAGE

XIV. On the Frequency Distribution of Phagocytic Counts. By M. GREENWOOD, Junr. and J. D. C. WHITE 376

XV. A Biometric Study of the Blood Corpuscles of the Common Tadpole. By KARL PEARSON, F.R.S. 402

XVI. Data on Variation in the Comb of the Domestic Fowl. By RAYMOND PEARL, Ph.D., and MAUD DEWITT PEARL 420

Miscellanea.

(i) Some Notes on Interpolation in n-dimensional Space. By W. PALIN ELDERTON 94

(ii) Note on the Relative Variability of the Sexes in *Carabus auratus*, L. By H. G. KRIBS 103

(iii) Variation in Flower-heads of *Gaillardia aristata*. By W. W. ROBBINS 106

(iv) The Effect of Errors of Observation upon the Correlation Coefficient. By J. A. COBB 109

(v) On Heredity in Sex. Remarks on Mr Cobb's Note. By KARL PEARSON, F.R.S. 109

(vi) On the Influence of Double Selection on the Variation and Correlation of two Characters. By KARL PEARSON, F.R.S. . . . 111

(vii) On certain Points concerning the Probable Error of the Standard Deviation. By RAYMOND PEARL, Ph.D. 112

(viii) Addendum to Memoir: "Split-Hand and Split-Foot Deformities." By THOMAS LEWIS, M.D. 117

(ix) On a Formula for Determining $\Gamma(x+1)$. EDITORIAL 118

(x) On the Inheritance of the Sex-Ratio in the Thoroughbred Racehorse. By DAVID HERON, M.A. 120

(xi) Note on Inheritance of Brachydactyly. By THOMAS LEWIS, M.D. . 327

(xii) Note on Inheritance in Man. By KARL PEARSON, F.R.S. . . . 327

(xiii) Fecundity of Swine. By FRANK M. SURFACE, Ph.D. 433

(xiv) The Frequency Constants of a Variable $z=f(x_1, x_2)$. By RAYMOND PEARL, Ph.D. 437

(xv) The Correlation between a Variable and the Deviation of a Dependent Variable from its Probable Value. By J. ARTHUR HARRIS, Ph.D. 438

Notices and Bibliography 123, 444

Plates.

PART I.

Plate I. Genealogical Tree of the "G" Family (Split-Foot) . . . . *to face p.* 27
Plate II. Photographs of Hands and Feet of members of G-family (Split-Foot) . . . . . „ 32
Plates III.—VII. Skiagrams of Hands and Feet of G-family „ 32
Plate VIII. Family Tree, Inherited Lobster-Claw . . „ 71
Plate IX. Diagrams illustrating defective hands of Lobster-Claw Family . . . . „ 74
Plate X. Diagrams illustrating defective feet of Lobster-Claw Family . . . . . . „ 74
Plate XI. Photograph of Hands of Mother and Daughters, Lobster-Claw Family . . . . „ 78
Plates XII.—XVI. Skiagrams of Hands and Feet of Lobster-Claw Family . . . . . . „ 78

PARTS II. AND III.

Plates I. and II. Maps of Scotland, showing the Pigmentation districts . . . . „ 137
Plates III.—XV. Maps of Scotland, illustrating the distribution of Hair and Eye Colour . . . . „ 232
Plates XVI.—XX. Diagrams, illustrating the Local Differences of Hair and Eye Colour in the Counties of Scotland . . . . „ 232
Plates XXI.—XXVI. Maps of Glasgow, illustrating the distribution of Hair and Eye Colour in Glasgow and Environs . . . . „ 232

PART III.

Plate I. Colour Variation in the Young of *Holothuria floridana*, Pourtalés . . . . . . to face p. 300
Plate II. Colour Variation in the Adult of *Holothuria floridana*, Pourtalés . . . . . „ 300
Plates III.—V. Papilla, pedicel, and calcareous spicules of *Holothuria floridana*, Pourtalés . . . . . „ 300
Folding Plate. *Holothuria floridana*, Pourtalés . . . . . „ 241

PART IV.

Photographs of Negro and White Crosses . . . . . „ 350

SPECIAL SUPPLEMENT TO VOL. VI.

Pigmentation Survey of School Children in Scotland. Appendix to Report. By J. F. TOCHER . . (Separate pagination) pp. 1—67

Erratum.

On p. 119, line 19, *for* "Since $\log x^x e^{-x} = {\cdot}848{,}4081$,"
read "Since $\log x^x e^{-x} = 3{\cdot}526{,}3058$."

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BIOMETRIKA.

THE PROBABLE ERROR OF A MEAN.

BY STUDENT.

Introduction.

ANY experiment may be regarded as forming an individual of a "population" of experiments which might be performed under the same conditions. A series of experiments is a sample drawn from this population.

Now any series of experiments is only of value in so far as it enables us to form a judgment as to the statistical constants of the population to which the experiments belong. In a great number of cases the question finally turns on the value of a mean, either directly, or as the mean difference between the two quantities.

If the number of experiments be very large, we may have precise information as to the value of the mean, but if our sample be small, we have two sources of uncertainty:—(1) owing to the "error of random sampling" the mean of our series of experiments deviates more or less widely from the mean of the population, and (2) the sample is not sufficiently large to determine what is the law of distribution of individuals. It is usual, however, to assume a normal distribution, because, in a very large number of cases, this gives an approximation so close that a small sample will give no real information as to the manner in which the population deviates from normality: since some law of distribution must be assumed it is better to work with a curve whose area and ordinates are tabled, and whose properties are well known. This assumption is accordingly made in the present paper, so that its conclusions are not strictly applicable to populations known not to be normally distributed; yet it appears probable that the deviation from normality must be very extreme to lead to serious error. We are concerned here solely with the first of these two sources of uncertainty.

The usual method of determining the probability that the mean of the population lies within a given distance of the mean of the sample, is to assume a normal distribution about the mean of the sample with a standard deviation equal to $s/\sqrt{n}$, where s is the standard deviation of the sample, and to use the tables of the probability integral.

But, as we decrease the number of experiments, the value of the standard deviation found from the sample of experiments becomes itself subject to an increasing error, until judgments reached in this way may become altogether misleading.

In routine work there are two ways of dealing with this difficulty: (1) an experiment may be repeated many times, until such a long series is obtained that the standard deviation is determined once and for all with sufficient accuracy. This value can then be used for subsequent shorter series of similar experiments. (2) Where experiments are done in duplicate in the natural course of the work, the mean square of the difference between corresponding pairs is equal to the standard deviation of the population multiplied by $\sqrt{2}$. We can thus combine together several series of experiments for the purpose of determining the standard deviation. Owing however to secular change, the value obtained is nearly always too low, successive experiments being positively correlated.

There are other experiments, however, which cannot easily be repeated very often; in such cases it is sometimes necessary to judge of the certainty of the results from a very small sample, which itself affords the only indication of the variability. Some chemical, many biological, and most agricultural and large scale experiments belong to this class, which has hitherto been almost outside the range of statistical enquiry.

Again, although it is well known that the method of using the normal curve is only trustworthy when the sample is "large," no one has yet told us very clearly where the limit between "large" and "small" samples is to be drawn.

The aim of the present paper is to determine the point at which we may use the tables of the probability integral in judging of the significance of the mean of a series of experiments, and to furnish alternative tables for use when the number of experiments is too few.

The paper is divided into the following nine sections:

I. The equation is determined of the curve which represents the frequency distribution of standard deviations of samples drawn from a normal population.

II. There is shown to be no kind of correlation between the mean and the standard deviation of such a sample.

III. The equation is determined of the curve representing the frequency distribution of a quantity z, which is obtained by dividing the distance between the mean of a sample and the mean of the population by the standard deviation of the sample.

IV. The curve found in I. is discussed.

V. The curve found in III. is discussed.

VI. The two curves are compared with some actual distributions.

VII. Tables of the curves found in III. are given for samples of different size.

VIII and IX. The tables are explained and some instances are given of their use.

X. Conclusions.

SECTION I.

Samples of n individuals are drawn out of a population distributed normally, to find an equation which shall represent the frequency of the standard deviations of these samples.

If s be the standard deviation found from a sample $x_1\, x_2 \ldots x_n$ (all these being measured from the mean of the population), then

$$s^2 = \frac{S(x_1^2)}{n} - \left(\frac{S(x_1)}{n}\right)^2 = \frac{S(x_1^2)}{n} - \frac{S(x_1^2)}{n^2} - \frac{2S(x_1 x_2)}{n^2}.$$

Summing for all samples and dividing by the number of samples we get the mean value of s^2 which we will write $\bar{s}^2$,

$$\bar{s}^2 = \frac{n\mu_2}{n} - \frac{n\mu_2}{n^2} = \frac{\mu_2(n-1)}{n},$$

where μ_2 is the second moment coefficient in the original normal distribution of x: since x_1, x_2, etc., are not correlated and the distribution is normal, products involving odd powers of x_1 vanish on summing, so that $\frac{2S(x_1 x_2)}{n^2}$ is equal to 0.

If M_R' represent the R^{th} moment coefficient of the distribution of s^2 about the end of the range where $s^2 = 0$,

$$M_1' = \mu_2 \frac{(n-1)}{n}.$$

Again

$$\begin{aligned} s^4 &= \left\{\frac{S(x_1^2)}{n} - \left(\frac{S(x_1)}{n}\right)^2\right\}^2 \\ &= \left(\frac{S(x_1^2)}{n}\right)^2 - \frac{2S(x_1^2)}{n}\left(\frac{S(x_1)}{n}\right)^2 + \left(\frac{S(x_1)}{n}\right)^4 \\ &= \frac{S(x_1^4)}{n^2} + \frac{2S(x_1^2 x_2^2)}{n^2} - \frac{2S(x_1^4)}{n^3} - \frac{4S(x_1^2 x_2^2)}{n^3} + \frac{S(x_1^4)}{n^4} \\ &\quad + \frac{6S(x_1^2 x_2^2)}{n^4} + \text{other terms involving odd powers of } x_1 \text{ etc.,} \\ &\qquad\qquad \text{which will vanish on summation.} \end{aligned}$$

Now $S(x_1^4)$ has n terms but $S(x_1^2 x_2^2)$ has $\frac{1}{2}n(n-1)$, hence summing for all samples and dividing by the number of samples we get

$$\begin{aligned} M_2' &= \frac{\mu_4}{n} + \mu_2^2 \frac{(n-1)}{n} - \frac{2\mu_4}{n^2} - 2\mu_2^2 \frac{(n-1)}{n^2} + \frac{\mu_4}{n^3} + 3\mu_2^2 \frac{(n-1)}{n^3} \\ &= \frac{\mu_4}{n}\{n^2 - 2n - 1\} + \frac{\mu_2^2}{n^3}(n-1)\{n^2 - 2n + 3\}. \end{aligned}$$

Now since the distribution of x is normal, $\mu_4 = 3\mu_2^2$, hence

$$M_2' = \mu_2^2 \frac{(n-1)}{n^3}\{3n - 3 + n^2 - 2n + 3\} = \mu_2^2 \frac{(n-1)(n+1)}{n^2}.$$

In a similar tedious way I find:

$$M_3' = \mu_2^3 \frac{(n-1)(n+1)(n+3)}{n^3},$$

and

$$M_4' = \mu_2^4 \frac{(n-1)(n+1)(n+3)(n+5)}{n^4}.$$

The law of formation of these moment coefficients appears to be a simple one, but I have not seen my way to a general proof.

If now M_R be the R^{th} moment coefficient of s^2 about its mean, we have

$$M_2 = \mu_2^2 \frac{(n-1)}{n^2} \{(n+1) - (n-1)\} = 2\mu_2^2 \frac{(n-1)}{n^2},$$

$$M_3 = \mu_2^3 \left\{ \frac{(n-1)(n+1)(n+3)}{n^3} - \frac{3(n-1)}{n} \cdot \frac{2(n-1)}{n^2} - \frac{(n-1)^3}{n^3} \right\}$$

$$= \mu_2^3 \frac{(n-1)}{n^3} \{n^2 + 4n + 3 - 6n + 6 - n^2 + 2n - 1\} = 8\mu_2^3 \frac{(n-1)}{n^3},$$

$$M_4 = \frac{\mu_2^4}{n^4} \{(n-1)(n+1)(n+3)(n+5) - 32(n-1)^2 - 12(n-1)^3 - (n-1)^4\}$$

$$= \frac{\mu_2^4 (n-1)}{n^4} \{n^3 + 9n^2 + 23n + 15 - 32n + 32 - 12n^2 + 24n - 12 - n^3 + 3n^2 - 3n + 1\}$$

$$= \frac{12\mu_2^4 (n-1)(n+3)}{n^4}.$$

Hence

$$\beta_1 = \frac{M_3^2}{M_2^3} = \frac{8}{n-1}, \quad \beta_2 = \frac{M_4}{M_2^2} = \frac{3(n+3)}{n-1},$$

$$\therefore \; 2\beta_2 - 3\beta_1 - 6 = \frac{1}{n-1} \{6(n+3) - 24 - 6(n-1)\} = 0.$$

Consequently a curve of Professor Pearson's type III. may be expected to fit the distribution of s^2.

The equation referred to an origin at the zero end of the curve will be

$$y = Cx^p e^{-\gamma x},$$

where

$$\gamma = 2\frac{M_2}{M_3} = \frac{4\mu_2^2 (n-1) n^3}{8n^2 \mu_2^3 (n-1)} = \frac{n}{2\mu_2},$$

and

$$p = \frac{4}{\beta_1} - 1 = \frac{n-1}{2} - 1 = \frac{n-3}{2}.$$

Consequently the equation becomes

$$y = Cx^{\frac{n-3}{2}} e^{-\frac{nx}{2\mu_2}},$$

which will give the distribution of s^2.

The area of this curve is $C\int_0^\infty x^{\frac{n-3}{2}} e^{-\frac{nx}{2\mu_2}} dx = I$ (say).

The first moment coefficient about the end of the range will therefore be

$$\frac{C\int_0^\infty x^{\frac{n-1}{2}} e^{-\frac{nx}{2\mu_2}}dx}{I} = \frac{C\left[\frac{-2\mu_2}{n} x^{\frac{n-1}{2}} e^{-\frac{nx}{2\mu_2}}\right]_{x=0}^{x=\infty}}{I} + \frac{C\int_0^\infty \frac{n-1}{n}\mu_2 x^{\frac{n-3}{2}} e^{-\frac{nx}{2\mu_2}}dx}{I}.$$

The first part vanishes at each limit and the second is equal to

$$\frac{\frac{n-1}{n}\mu_2 I}{I} = \frac{n-1}{n}\mu_2,$$

and we see that the higher moment coefficients will be formed by multiplying successively by $\frac{n+1}{n}\mu_2$, $\frac{n+3}{n}\mu_2$, etc., just as appeared to be the law of formation of M_2', M_3', M_4', etc.

Hence it is probable that the curve found represents the theoretical distribution of s^2; so that although we have no actual proof we shall assume it to do so in what follows.

The distribution of s may be found from this, since the frequency of s is equal to that of s^2 and all that we must do is to compress the base line suitably.

Now if $y_1 = \phi(s^2)$ be the frequency curve of s^2

and $y_2 = \psi(s)$ " " " " s,

then $y_1 d(s^2) = y_2 ds$,

or $y_2 ds = 2y_1 s ds$,

$\therefore \quad y_2 = 2sy_1$.

Hence $$y_2 = 2Cs(s^2)^{\frac{n-3}{2}} e^{-\frac{ns^2}{2\mu_2}}$$

is the distribution of s.

This reduces to $$y_2 = 2Cs^{n-2} e^{-\frac{ns^2}{2\mu_2}}.$$

Hence $y = Ax^{n-2} e^{-\frac{nx^2}{2\sigma^2}}$ will give the frequency distribution of standard deviations of samples of n, taken out of a population distributed normally with standard deviation σ. The constant A may be found by equating the area of the curve as follows:—

$$\text{Area} = A\int_0^\infty x^{n-2} e^{-\frac{nx^2}{2\sigma^2}}dx. \quad \left(\text{Let } I_p \text{ represent } \int_0^\infty x^p e^{-\frac{nx^2}{2\sigma^2}}dx.\right)$$

Then
$$\begin{aligned} I_p &= \frac{\sigma^2}{n}\int_0^\infty x^{p-1}\frac{d}{dx}\left(-e^{-\frac{nx^2}{2\sigma^2}}\right)dx \\ &= \frac{\sigma^2}{n}\left[-x^{p-1}e^{-\frac{nx^2}{2\sigma^2}}\right]_{x=0}^{x=\infty} + \frac{\sigma^2}{n}(p-1)\int_0^\infty x^{p-2}e^{-\frac{nx^2}{2\sigma^2}}dx \\ &= \frac{\sigma^2}{n}(p-1)I_{p-2}, \end{aligned}$$

since the first part vanishes at both limits.

By continuing this process we find

$$I_{n-2} = \left(\frac{\sigma^2}{n}\right)^{\frac{n-2}{2}} (n-3)(n-5)\ldots 3 \,.\, 1\, I_0$$

or

$$= \left(\frac{\sigma^2}{n}\right)^{\frac{n-3}{2}} (n-3)(n-5)\ldots 4 \,.\, 2\, I_1$$

according as n is even or odd.

But I_0 is

$$\int_0^\infty e^{-\frac{nx^2}{2\sigma^2}} dx = \sqrt{\frac{\pi}{2n}}\,\sigma,$$

and I_1 is

$$\int_0^\infty x e^{-\frac{nx^2}{2\sigma^2}} dx = \left[-\frac{\sigma^2}{n} e^{-\frac{nx^2}{2\sigma^2}}\right]_{x=0}^{x=\infty} = \frac{\sigma^2}{n}.$$

Hence if n be even,

$$A = \frac{\text{Area}}{(n-3)(n-5)\ldots 3 \,.\, 1 \sqrt{\frac{\pi}{2}} \left(\frac{\sigma^2}{n}\right)^{\frac{n-1}{2}}},$$

and if n be odd

$$A = \frac{\text{Area}}{(n-3)(n-5)\ldots 4 \,.\, 2 \left(\frac{\sigma^2}{n}\right)^{\frac{n-1}{2}}}.$$

Hence the equation may be written

$$y = \frac{N}{(n-3)(n-5)\ldots 3 \,.\, 1} \sqrt{\frac{2}{\pi}} \left(\frac{n}{\sigma^2}\right)^{\frac{n-1}{2}} x^{n-2} e^{-\frac{nx^2}{2\sigma^2}} \; (n \text{ even})$$

or

$$y = \frac{N}{(n-3)(n-5)\ldots 4 \,.\, 2} \left(\frac{n}{\sigma^2}\right)^{\frac{n-1}{2}} x^{n-2} e^{-\frac{nx^2}{2\sigma^2}} \; (n \text{ odd})$$

where N as usual represents the total frequency.

SECTION II.

To show that there is no correlation between (*a*) the distance of the mean of a sample from the mean of the population and (*b*) the standard deviation of a sample with normal distribution.

(1) Clearly positive and negative positions of the mean of the sample are equally likely, and hence there cannot be correlation between the absolute value of the distance of the mean from the mean of the population and the standard deviation, but (2) there might be correlation between the square of the distance and the square of the standard deviation.

Let

$$u^2 = \left(\frac{S(x_1)}{n}\right)^2 \quad \text{and} \quad s^2 = \frac{S(x_1^2)}{n} - \left(\frac{S(x_1)}{n}\right)^2.$$

Then if m_1', M_1' be the mean values of u^2 and s^2, we have by the preceding part $M_1' = \mu_2 \frac{(n-1)}{n}$ and $m_1' = \frac{\mu_2}{n}$.

Now $u^2s^2 = \frac{S(x_1^2)}{n}\left(\frac{S(x_1)}{n}\right)^2 - \left(\frac{S(x_1)}{n}\right)^4$

$$= \left(\frac{S(x_1^2)}{n}\right)^2 + 2\,\frac{S(x_1x_2)\,.\,S(x_1^2)}{n^3} - \frac{S(x_1^4)}{n^4}$$

$- \frac{6x_1^2x_2^2}{n^4}$ − other terms of odd order which will vanish on summation.

Summing for all values and dividing by the number of cases we get

$$R_{u^2s^2}\sigma_{u^2}\sigma_{s^2} + m_1M_1 = \frac{\mu_4}{n^2} + \mu_2^2\frac{(n-1)}{n^2} - \frac{\mu_4}{n^3} - 3\mu_2^2\frac{(n-1)}{n^3},$$

where $R_{u^2s^2}$ is the correlation between u^2 and s^2.

$$R_{u^2s^2}\sigma_{u^2}\sigma_{s^2} + \mu_2^2\frac{(n-1)}{n^2} = \mu_2^2\frac{(n-1)}{n^3}\{3 + n - 3\} = \mu_2^2\frac{(n-1)}{n^2}.$$

Hence $R_{u^2s^2}\sigma_{u^2}\sigma_{s^2} = 0$ or there is no correlation between u^2 and s^2.

SECTION III.

To find the equation representing the frequency distribution of the means of samples of n drawn from a normal population, the mean being expressed in terms of the standard deviation of the sample.

We have $y = \frac{C}{\sigma^{n-1}}s^{n-2}e^{-\frac{ns^2}{2\sigma^2}}$ as the equation representing the distribution of s, the standard deviation of a sample of n, when the samples are drawn from a normal population with standard deviation σ.

Now the means of these samples of n are distributed according to the equation

$$y = \frac{\sqrt{n}N}{\sqrt{2\pi}\sigma}e^{-\frac{nx^2}{2\sigma^2}}\text{*}$$

and we have shown that there is no correlation between x, the distance of the mean of the sample, and s, the standard deviation of the sample.

Now let us suppose x measured in terms of s, *i.e.* let us find the distribution of $z = \frac{x}{s}$.

If we have $y_1 = \phi(x)$ and $y_2 = \psi(z)$ as the equations representing the frequency of x and of z respectively, then

$$y_1dx = y_2dz = y_2\frac{dx}{s},$$

$$\therefore\ y_2 = sy_1.$$

---

* Airy, *Theory of Errors of Observations*, Part II. § 6.

Hence
$$y=\frac{N\sqrt{ns}}{\sqrt{2\pi}\,\sigma}e^{-\frac{ns^2z^2}{2\sigma^2}}$$
is the equation representing the distribution of z for samples of n with standard deviation s.

Now the chance that s lies between s and $s+ds$ is:
$$\frac{\int_s^{s+ds}\frac{C}{\sigma^{n-1}}s^{n-2}e^{-\frac{ns^2}{2\sigma^2}}ds}{\int_0^{\infty}\frac{C}{\sigma^{n-1}}s^{n-2}e^{-\frac{ns^2}{2\sigma^2}}ds},$$
which represents the N in the above equation.

Hence the distribution of z due to values of s which lie between s and $s+ds$ is
$$y=\frac{\int_s^{s+ds}\frac{C}{\sigma^n}\sqrt{\frac{n}{2\pi}}s^{n-1}e^{-\frac{ns^2(1+z^2)}{2\sigma^2}}ds}{\int_0^{\infty}\frac{C}{\sigma^{n-1}}s^{n-2}e^{-\frac{ns^2}{2\sigma^2}}ds}=\frac{\sqrt{\frac{n}{2\pi}}\int_s^{s+ds}s^{n-1}e^{-\frac{ns^2(1+z^2)}{2\sigma^2}}ds}{\sigma\int_0^{\infty}s^{n-2}e^{-\frac{ns^2}{2\sigma^2}}ds},$$
and summing for all values of s we have as an equation giving the distribution of z
$$y=\frac{\sqrt{\frac{n}{2\pi}}}{\sigma}\frac{\int_0^{\infty}s^{n-1}e^{-\frac{ns^2(1+z^2)}{2\sigma^2}}ds}{\int_0^{\infty}s^{n-2}e^{-\frac{ns^2}{2\sigma^2}}ds}.$$

By what we have already proved this reduces to
$$y=\frac{1}{2}\frac{n-2}{n-3}\cdot\frac{n-4}{n-5}\cdots\frac{5}{4}\cdot\frac{3}{2}(1+z^2)^{-\frac{n}{2}}\text{ if } n \text{ be odd,}$$
and to
$$y=\frac{1}{\pi}\frac{n-2}{n-3}\cdot\frac{n-4}{n-5}\cdots\frac{4}{3}\cdot\frac{2}{1}(1+z^2)^{-\frac{n}{2}}\text{ if } n \text{ be even.}$$

Since this equation is independent of σ it will give the distribution of the distance of the mean of a sample from the mean of the population expressed in terms of the standard deviation of the sample for any normal population.

SECTION IV.

Some Properties of the Standard Deviation Frequency Curve.

By a similar method to that adopted for finding the constant we may find the mean and moments: thus the mean is at $\frac{I_{n-1}}{I_{n-2}}$,

which is equal to
$$\frac{(n-2)(n-4)}{(n-3)(n-5)}\cdots\frac{2}{1}\sqrt{\frac{2}{\pi}}\frac{\sigma}{\sqrt{n}}\text{ (if } n \text{ be even),}$$
or
$$\frac{(n-2)(n-4)}{(n-3)(n-5)}\cdots\frac{3}{2}\sqrt{\frac{\pi}{2}}\frac{\sigma}{\sqrt{n}}\text{ (if } n \text{ be odd).}$$

The second moment about the end of the range is

$$\frac{I_n}{I_{n-2}} = \frac{(n-1)\,\sigma^2}{n}.$$

The third moment about the end of the range is equal to

$$\frac{I_{n+1}}{I_{n-2}} = \frac{I_{n+1}}{I_{n-1}} \cdot \frac{I_{n-1}}{I_{n-2}}$$

$$= \sigma^2 \times \text{the mean.}$$

The fourth moment about the end of the range is equal to

$$\frac{I_{n+2}}{I_{n-2}} = \frac{(n-1)(n+1)}{n^2}\,\sigma^4.$$

If we write the distance of the mean from the end of the range $\frac{D\sigma}{\sqrt{n}}$ and the moments about the end of the range ν_1, ν_2, etc.

then $$\nu_1 = \frac{D\sigma}{\sqrt{n}}, \quad \nu_2 = \frac{n-1}{n}\sigma^2, \quad \nu_3 = \frac{D\sigma^3}{\sqrt{n}}, \quad \nu_4 = \frac{n^2-1}{n^2}\sigma^4.$$

From this we get the moments about the mean

$$\mu_2 = \frac{\sigma^2}{n}(n-1-D^2),$$

$$\mu_3 = \frac{\sigma^3}{n\sqrt{n}}\{nD - 3(n-1)D + 2D^3\} = \frac{\sigma^3 D}{n\sqrt{n}}\{2D^2 - 2n + 3\},$$

$$\mu_4 = \frac{\sigma^2}{n^2}\{n^2 - 1 - 4D^2 n + 6(n-1)D^2 - 3D^4\} = \frac{\sigma^4}{n^2}\{n^2 - 1 - D^2(3D^2 - 2n + 6)\}.$$

It is of interest to find out what these become when n is large.

In order to do this we must find out what is the value of D.

Now Wallis's expression for π derived from the infinite product value of $\sin x$ is

$$\frac{\pi}{2}(2n+1) = \frac{2^2 \,.\, 4^2 \,.\, 6^2 \ldots (2n)^2}{1^2 \,.\, 3^2 \,.\, 5^2 \ldots (2n-1)^2}.$$

If we assume a quantity $\theta \left(= a_0 + \frac{a_1}{n} + \text{etc.}\right)$ which we may add to the $2n+1$ in order to make the expression approximate more rapidly to the truth, it is easy to show that $\theta = -\frac{1}{2} + \frac{1}{16n} - \text{etc.}$ and we get

$$\frac{\pi}{2}\left(2n + \frac{1}{2} + \frac{1}{16n}\right) = \frac{2^2 \,.\, 4^2 \,.\, 6^2 \ldots (2n)^2}{1^2 \,.\, 3^2 \,.\, 5^2 \ldots (2n-1)^2}.\text{*}$$

From this we find that whether n be even or odd D^2 approximates to $n - \frac{3}{2} + \frac{1}{8n}$ when n is large.

---

* This expression will be found to give a much closer approximation to π than Wallis's.

Substituting this value of D we get

$$\mu_2 = \frac{\sigma^2}{2n}\left(1 - \frac{1}{4n}\right), \qquad \mu_3 = \frac{\sigma^3\sqrt{1 - \frac{3}{2n} + \frac{1}{16n^2}}}{4n^2}, \qquad \mu_4 = \frac{3\sigma^4}{4n^2}\left(1 + \frac{1}{2n} - \frac{1}{16n^2}\right).$$

Consequently the value of the standard deviation of a standard deviation which we have found $\left(\frac{\sigma}{\sqrt{2n}\sqrt{1 - \frac{1}{4n}}}\right)$ becomes the same as that found for the normal curve by Professor Pearson $(\sigma/\sqrt{2n})$ when n is large enough to neglect the $1/4n$ in comparison with 1.

Neglecting terms of lower order than $\frac{1}{n}$ we find

$$\beta_1 = \frac{2n-3}{n(4n-3)}, \qquad \beta_2 = 3\left(1 - \frac{1}{2n}\right)\left(1 + \frac{1}{2n}\right).$$

Consequently as n increases β_2 very soon approaches the value 3 of the normal curve, but β_1 vanishes more slowly, so that the curve remains slightly skew.

Diagram I. Frequency curve giving the distribution of Standard Deviations of samples of 10 taken from a normal population.

Equation $y = \frac{N}{7.5.3}\frac{10^{\frac{9}{2}}}{\sigma^9}\sqrt{\frac{2}{\pi}}\,x^8 e^{-\frac{10x^2}{2\sigma^2}}$.

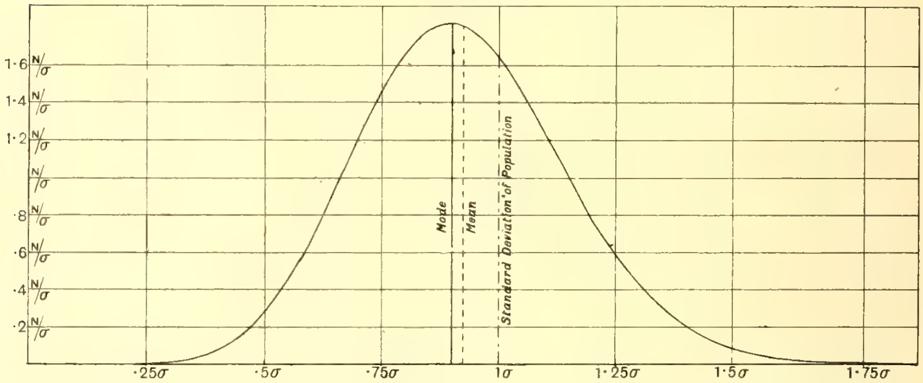


Diagram I shows the theoretical distribution of the S.D. found from samples of 10.

$$y = \frac{N\,10^{\frac{9}{2}}}{7.5.3}\sqrt{\frac{2}{\pi}}\frac{x^8}{\sigma^9}e^{-\frac{10x^2}{2\sigma^2}}.$$

SECTION V.

Some properties of the curve $y = \frac{n-2}{n-3}\cdot\frac{n-4}{n-5}\cdots\left(\begin{matrix}\frac{4}{3}\cdot\frac{2}{\pi}\text{ if } n \text{ be even}\\ \frac{5}{4}\cdot\frac{3}{2}\text{ if } n \text{ be odd}\end{matrix}\right)(1+z^2)^{-\frac{n}{2}}$.

Writing $z = \tan\theta$ the equation becomes $y = \frac{n-2}{n-3}\cdot\frac{n-4}{n-5}\ldots$ etc. $\times \cos^n\theta$, which affords an easy way of drawing the curve. Also $dz = d\theta/\cos^2\theta$.

Hence to find the area of the curve between any limits we must find

$$\frac{n-2}{n-3} \cdot \frac{n-4}{n-5} \ldots \text{etc.} \times \int \cos^{n-2} \theta d\theta$$

$$= \frac{n-2}{n-3} \cdot \frac{n-4}{n-5} \ldots \text{etc.} \left\{ \frac{n-3}{n-2} \int \cos^{n-4} \theta d\theta + \left[\frac{\cos^{n-3} \theta \sin \theta}{n-2} \right] \right\}$$

$$= \frac{n-4}{n-5} \cdot \frac{n-6}{n-7} \ldots \text{etc.} \int \cos^{n-4} \theta d\theta + \frac{1}{n-3} \cdot \frac{n-4}{n-5} \ldots \text{etc.} \left[\cos^{n-3} \theta \sin \theta \right],$$

and by continuing the process the integral may be evaluated.

For example, if we wish to find the area between 0 and θ for $n=8$ we have

$$\text{area} = \frac{6}{5} \cdot \frac{4}{3} \cdot \frac{2}{1} \cdot \frac{1}{\pi} \int_0^\theta \cos^6 \theta d\theta$$

$$= \frac{4}{3} \cdot \frac{2}{\pi} \cdot \int_0^\theta \cos^4 \theta d\theta + \frac{1}{5} \cdot \frac{4}{3} \cdot \frac{2}{\pi} \cos^5 \theta \sin \theta$$

$$= \frac{\theta}{\pi} + \frac{1}{\pi} \cos \theta \sin \theta + \frac{1}{3} \cdot \frac{2}{\pi} \cos^3 \theta \sin \theta + \frac{1}{5} \cdot \frac{4}{3} \cdot \frac{2}{\pi} \cos^5 \theta \sin \theta,$$

and it will be noticed that for $n=10$ we shall merely have to add to this same expression the term $\frac{1}{7} \cdot \frac{6}{5} \cdot \frac{4}{3} \cdot \frac{2}{\pi} \cos^7 \theta \sin \theta$.

The tables at the end of the paper give the area between $-\infty$ and z

$$\left(\text{or } \theta = -\frac{\pi}{2} \text{ and } \theta = \tan^{-1} z \right).$$

This is the same as $\cdot 5 +$ the area between $\theta = 0$, and $\theta = \tan^{-1} z$, and as the whole area of the curve is equal to 1, the tables give the probability that the mean of the sample does not differ by more than z times the standard deviation of the sample from the mean of the population.

The whole area of the curve is equal to

$$\frac{n-2}{n-3} \cdot \frac{n-4}{n-5} \ldots \text{etc.} \times \int_{-\frac{\pi}{2}}^{+\frac{\pi}{2}} \cos^{n-2} \theta d\theta,$$

and since all the parts between the limits vanish at both limits this reduces to 1.

Similarly the second moment coefficient is equal to

$$\frac{n-2}{n-3} \cdot \frac{n-4}{n-5} \ldots \text{etc.} \times \int_{-\frac{\pi}{2}}^{+\frac{\pi}{2}} \cos^{n-2} \theta \tan^2 \theta d\theta$$

$$= \frac{n-2}{n-3} \cdot \frac{n-4}{n-5} \ldots \text{etc.} \times \int_{-\frac{\pi}{2}}^{+\frac{\pi}{2}} (\cos^{n-4} \theta - \cos^{n-2} \theta) \, d\theta$$

$$= \frac{n-2}{n-3} - 1 = \frac{1}{n-3}.$$

Hence the standard deviation of the curve is $1/\sqrt{n-3}$. The fourth moment coefficient is equal to

$$\frac{n-2}{n-3}\cdot\frac{n-4}{n-5}\dots\text{etc.}\times\int_{-\frac{\pi}{2}}^{+\frac{\pi}{2}}\cos^{n-2}\theta\tan^4\theta\,d\theta$$

$$=\frac{n-2}{n-3}\cdot\frac{n-4}{n-5}\dots\text{etc.}\times\int_{-\frac{\pi}{2}}^{+\frac{\pi}{2}}(\cos^{n-6}\theta-2\cos^{n-4}\theta+\cos^{n-2}\theta)\,d\theta$$

$$=\frac{n-2}{n-3}\cdot\frac{n-4}{n-5}-\frac{2(n-2)}{n-3}+1=\frac{3}{(n-3)(n-5)}.$$

The odd moments are of course zero as the curve is symmetrical, so

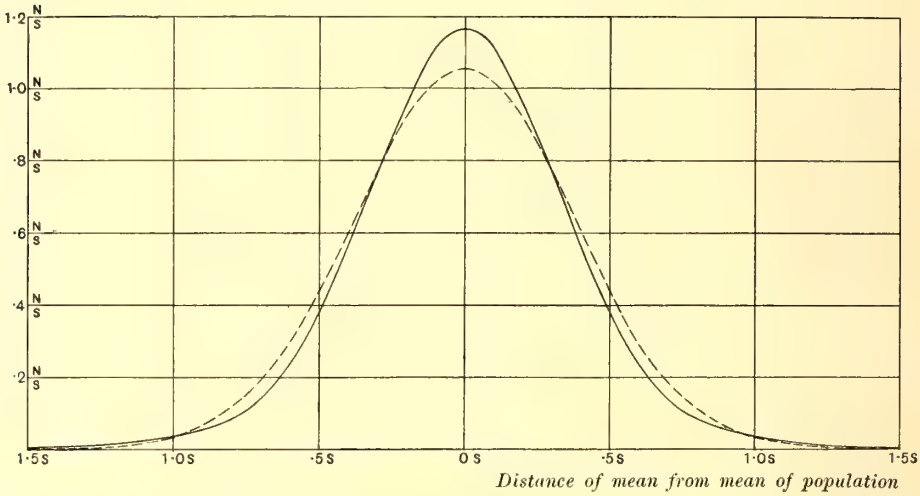
$$\beta_1=0,\qquad \beta_2=\frac{3(n-3)}{n-5}=3+\frac{2}{n-5}.$$

Hence as n increases the curve approaches the normal curve whose standard deviation is $1/\sqrt{n-3}$.

β_2 however is always greater than 3, indicating that large deviations are more common than in the normal curve.

DIAGRAM II. Solid curve $y=\frac{N}{S}\times\frac{8}{7}\cdot\frac{6}{5}\cdot\frac{4}{3}\cdot\frac{2}{\pi}\cos^{10}\theta$, $x/s=\tan\theta$.

Broken line curve $y=\frac{\sqrt{7}.N}{\sqrt{2\pi}.s}e^{-\frac{7x^2}{2s^2}}$, the normal curve with the same S.D.



I have tabled the area for the normal curve with standard deviation $1/\sqrt{7}$ so as to compare with my curve for $n=10$*. It will be seen that odds laid according to either table would not seriously differ till we reach $z=\cdot 8$, where the odds are about 50 to 1 that the mean is within that limit: beyond that the normal curve gives a false feeling of security, for example, according to the normal curve it is 99,986 to 14 (say 7000 to 1) that the mean of the population lies between $-\infty$ and $+1\cdot 3s$ whereas the real odds are only 99,819 to 181 (about 550 to 1).

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* See p. 19.

Now 50 to 1 corresponds to three times the probable error in the normal curve and for most purposes would be considered significant; for this reason I have only tabled my curves for values of n not greater than 10, but have given the $n=9$ and $n=10$ tables to one further place of decimals. They can be used as foundations for finding values for larger samples*.

The table for $n=2$ can be readily constructed by looking out $\theta=\tan^{-1}z$ in Chambers' Tables and then $\cdot 5+\theta/\pi$ gives the corresponding value.

Similarly $\frac{1}{2}\sin\theta+\cdot 5$ gives the values when $n=3$.

There are two points of interest in the $n=2$ curve. Here s is equal to half the distance between the two observations. $\tan^{-1}\frac{s}{s}=\frac{\pi}{4}$ so that between $+s$ and $-s$ lies $2\times\frac{\pi}{4}\times\frac{1}{\pi}$ or half the probability, i.e. if two observations have been made and we have no other information, it is an even chance that the mean of the (normal) population will lie between them. On the other hand the second moment coefficient is

$$\frac{1}{\pi}\int_{-\frac{\pi}{2}}^{+\frac{\pi}{2}}\tan^2\theta\,d\theta=\frac{1}{\pi}\Big[\tan\theta-\theta\Big]_{-\frac{\pi}{2}}^{\frac{\pi}{2}}=\infty,$$

or the standard deviation is infinite while the probable error is finite.

SECTION VI. *Practical Test of the foregoing Equations.*

Before I had succeeded in solving my problem analytically, I had endeavoured to do so empirically. The material used was a correlation table containing the height and left middle finger measurements of 3000 criminals, from a paper by W. R. Macdonell (*Biometrika*, Vol. I. p. 219). The measurements were written out on 3000 pieces of cardboard, which were then very thoroughly shuffled and drawn at random. As each card was drawn its numbers were written down in a book which thus contains the measurements of 3000 criminals in a random order. Finally each consecutive set of 4 was taken as a sample—750 in all—and the mean, standard deviation, and correlation† of each sample determined. The difference between the mean of each sample and the mean of the population was then divided by the standard deviation of the sample, giving us the z of Section III.

This provides us with two sets of 750 standard deviations and two sets of 750 z's on which to test the theoretical results arrived at. The height and left middle finger correlation table was chosen because the distribution of both was approximately normal and the correlation was fairly high. Both frequency curves, however, deviate slightly from normality, the constants being for height $\beta_1=\cdot 0026$, $\beta_2=3\cdot 175$, and for left middle finger lengths $\beta_1=\cdot 0030$, $\beta_2=3\cdot 140$, and in consequence there is a tendency for a certain number of larger standard deviations to occur than if the distributions were normal. This, however, appears to make very little difference to the distribution of z.

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* E.g. if $n=11$, to the corresponding value for $n=9$, we add $\frac{7}{8}\times\frac{5}{6}\times\frac{3}{4}\times\frac{1}{2}\times\frac{1}{2}\cos^8\theta\sin\theta$: if $n=13$ we add as well $\frac{9}{10}\times\frac{7}{8}\times\frac{5}{6}\times\frac{3}{4}\times\frac{1}{2}\times\frac{1}{2}\cos^{10}\theta\sin\theta$ and so on.

† I hope to publish the results of the correlation work shortly.

Another thing which interferes with the comparison is the comparatively large groups in which the observations occur. The heights are arranged in 1 inch groups, the standard deviation being only 2·54 inches: while the finger lengths were originally grouped in millimetres, but unfortunately I did not at the time see the importance of having a smaller unit, and condensed them into two millimetre groups, in terms of which the standard deviation is 2·74.

Several curious results follow from taking samples of 4 from material disposed in such wide groups. The following points may be noticed:

(1) The means only occur as multiples of ·25.

(2) The standard deviations occur as the square roots of the following types of numbers n, $n+{\cdot}19$, $n+{\cdot}25$, $n+{\cdot}50$, $n+{\cdot}69$, $2n+{\cdot}75$.

(3) A standard deviation belonging to one of these groups can only be associated with a mean of a particular kind; thus a standard deviation of $\sqrt{2}$ can only occur if the mean differs by a whole number from the group we take as origin, while $\sqrt{1{\cdot}69}$ will only occur when the mean is at $n \pm {\cdot}25$.

(4) All the four individuals of the sample will occasionally come from the same group, giving a zero value for the standard deviation. Now this leads to an infinite value of z and is clearly due to too wide a grouping, for although two men may have the same height when measured by inches, yet the finer the measurements the more seldom will they be identical, till finally the chance that four men will have *exactly* the same height is infinitely small. If we had smaller grouping the zero values of the standard deviation might be expected to increase, and a similar consideration will show that the smaller values of the standard deviation would also be likely to increase, such as ·436, when 3 fall in one group and 1 in an adjacent group, or ·50 when 2 fall in two adjacent groups. On the other hand when the individuals of the sample lie far apart, the argument of Sheppard's correction will apply, the real value of the standard deviation being more likely to be smaller than that found owing to the frequency in any group being greater on the side nearer the mode.

These two effects of grouping will tend to neutralise each other in their effect on the mean value of the standard deviation, but both will increase the variability.

Accordingly we find that the mean value of the standard deviation is quite close to that calculated, while in each case the variability is sensibly greater. The fit of the curve is not good, both for this reason and because the frequency is not evenly distributed owing to effects (2) and (3) of grouping. On the other hand the fit of the curve giving the frequency of z is very good and as that is the only practical point the comparison may be considered satisfactory.

The following are the figures for height:—

Mean value of standard deviations; calculated 2·027 ± ·021

" " " observed 2·026

Difference = − ·001

Standard deviation of standard deviations:—

$$\begin{array}{ll} \text{Calculated} & \cdot 8556 \pm \cdot 015 \\ \text{Observed} & \cdot 9066 \\ \hline \end{array}$$

$$\text{Difference} = + \cdot 0510$$

Comparison of Fit. Theoretical Equation: $y = \frac{16 \times 750}{\sqrt{2\pi\sigma^3}} x^2 e^{-\frac{2x^2}{\sigma^2}}$.

Scale in terms of standard deviation of population	0 to ·1	·1 to ·2	·2 to ·3	·3 to ·4	·4 to ·5	·5 to ·6	·6 to ·7	·7 to ·8	·8 to ·9	·9 to 1·0	1·0 to 1·1	1·1 to 1·2	1·2 to 1·3	1·3 to 1·4	1·4 to 1·5	1·5 to 1·6	1·6 to 1·7	Greater than 1·7
Calculated frequency	$1\frac{1}{2}$	$10\frac{1}{2}$	27	$45\frac{1}{2}$	$64\frac{1}{2}$	$78\frac{1}{2}$	87	88	$81\frac{1}{2}$	71	58	45	33	23	15	$9\frac{1}{2}$	$5\frac{1}{2}$	7
Observed frequency	3	$14\frac{1}{2}$	$24\frac{1}{2}$	$37\frac{1}{2}$	107	67	73	77	$77\frac{1}{2}$	64	$52\frac{1}{2}$	$49\frac{1}{2}$	35	28	$12\frac{1}{2}$	9	$11\frac{1}{2}$	7
Difference	$+1\frac{1}{2}$	$+4$	$-2\frac{1}{2}$	-8	$+42\frac{1}{2}$	$-11\frac{1}{2}$	-14	-11	-4	-7	$-5\frac{1}{2}$	$+4\frac{1}{2}$	$+2$	$+5$	$-2\frac{1}{2}$	$-\frac{1}{2}$	$+6$	0

whence $\chi^2 = 48{\cdot}06$, $P = {\cdot}000{,}06$ (about).

In tabling the observed frequency, values between ·0125 and ·0875 were included in one group, while between ·0875 and ·0125 they were divided over the two groups. As an instance of the irregularity due to grouping I may mention that there were 31 cases of standard deviations 1·30 (in terms of the grouping) which is ·5117 in terms of the standard deviation of the population, and they were therefore divided over the groups ·4 to ·5 and ·5 to ·6. Had they all been counted in groups ·5 to ·6 χ^2 would have fallen to 29·85 and P would have risen to ·03. The χ^2 test presupposes *random* sampling from a frequency following the given law, but this we have not got owing to the interference of the grouping.

When, however, we test the z's where the grouping has not had so much effect we find a close correspondence between the theory and the actual result.

There were three cases of infinite values of z which, for the reasons given above, were given the next largest values which occurred, namely $+6$ or -6. The rest were divided into groups of ·1; ·04, ·05 and ·06, being divided between the two groups on either side.

The calculated value for the standard deviation of the frequency curve was 1 (± ·017) while the observed was 1·039. The value of the standard deviation is really infinite, as the fourth moment coefficient is infinite, but as we have arbitrarily limited the infinite cases we may take as an approximation $\frac{1}{\sqrt{1500}}$ from which the value of the probable error given above is obtained. The fit of the curve is as follows:—

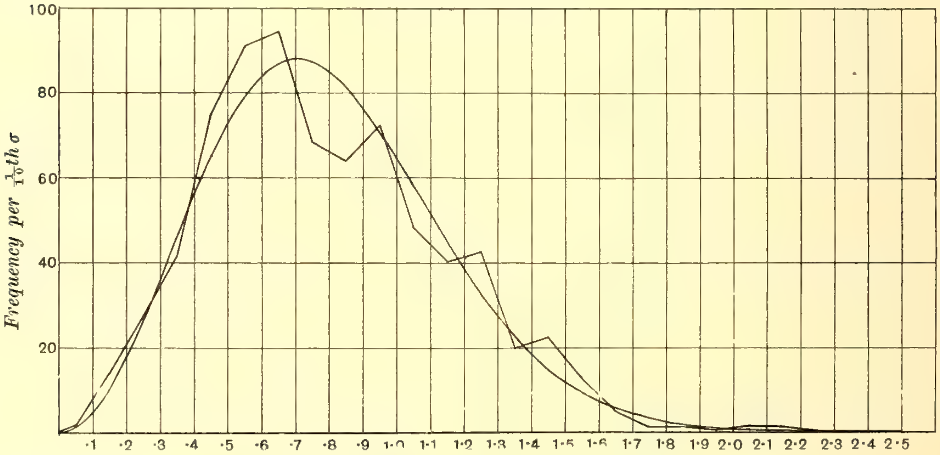
Comparison of Fit. Theoretical Equation: $y = \frac{2}{\pi}\cos^4\theta,\ z = \tan\theta$.

Scale of z	less than $-3{\cdot}05$	$-3{\cdot}05$ to $-2{\cdot}05$	$-2{\cdot}05$ to $-1{\cdot}55$	$-1{\cdot}55$ to $-1{\cdot}05$	$-1{\cdot}05$ to $-{\cdot}75$	$-{\cdot}75$ to $-{\cdot}45$	$-{\cdot}45$ to $-{\cdot}15$	$-{\cdot}15$ to $+{\cdot}15$	$+{\cdot}15$ to $+{\cdot}45$	$+{\cdot}45$ to $+{\cdot}75$	$+{\cdot}75$ to $+1{\cdot}05$	$+1{\cdot}05$ to $+1{\cdot}55$	$+1{\cdot}55$ to $+2{\cdot}05$	$+2{\cdot}05$ to $+3{\cdot}05$	more than $+3{\cdot}05$
Calculated frequency	5	$9\frac{1}{2}$	$13\frac{1}{2}$	$34\frac{1}{2}$	$44\frac{1}{2}$	$78\frac{1}{2}$	119	141	119	$78\frac{1}{2}$	$44\frac{1}{2}$	$34\frac{1}{2}$	$13\frac{1}{2}$	$9\frac{1}{2}$	5
Observed frequency	9	$14\frac{1}{2}$	$11\frac{1}{2}$	33	$43\frac{1}{2}$	$70\frac{1}{2}$	$119\frac{1}{2}$	$151\frac{1}{2}$	122	$67\frac{1}{2}$	49	$26\frac{1}{2}$	16	10	6
Difference	$+4$	$+5$	-2	$-1\frac{1}{2}$	-1	-8	$+\frac{1}{2}$	$+10\frac{1}{2}$	$+3$	-11	$+4\frac{1}{2}$	-8	$+2\frac{1}{2}$	$+\frac{1}{2}$	$+1$

whence $\chi^2 = 12{\cdot}44$, $P = {\cdot}56$.

This is very satisfactory, especially when we consider that as a rule observations are tested against curves fitted from the mean and one or more other moments of the observations, so that considerable correspondence is only to be expected; while this curve is exposed to the full errors of random sampling, its constants having been calculated quite apart from the observations.

Diagram III. Comparison of Calculated Standard Deviation Frequency Curve with 750 actual Standard Deviations.



Scale of Standard Deviation of the Population

The left middle finger samples show much the same features as those of the height, but as the grouping is not so large compared to the variability the curves fit the observations more closely. Diagrams III.* and IV. give the standard deviations and the z's for this set of samples. The results are as follows:—

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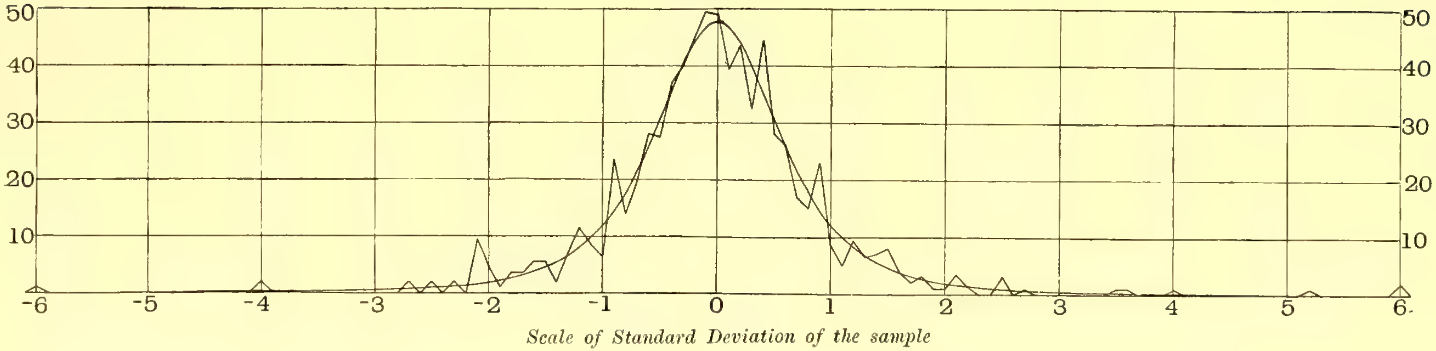
* There are three small mistakes in plotting the observed values in Diagram III., which make the fit appear worse than it really is.

DIAGRAM IV. Comparison of the theoretical frequency curve $y = \frac{1500}{\pi}\left(1+\frac{x^2}{s^2}\right)^{-2}$, with an actual sample of 750 cases.



Mean value of standard deviations; calculated 2·186 ± ·023
„ „ „ observed 2·179
Difference = − ·007

Standard deviation of standard deviations:—

Calculated ·9224 ± ·016
Observed ·9802
Difference = + ·0578

Comparison of Fit. Theoretical Equation: $y = \frac{16 \times 750}{\sqrt{2\pi}\sigma^3} x^2 e^{-\frac{2x^2}{\sigma^2}}$.

Scale in terms of standard deviation of population	*0 to ·1*	*·1 to ·2*	*·2 to ·3*	*·3 to ·4*	*·4 to ·5*	*·5 to ·6*	*·6 to ·7*	*·7 to ·8*	*·8 to ·9*	*·9 to 1·0*	*1·0 to 1·1*	*1·1 to 1·2*	*1·2 to 1·3*	*1·3 to 1·4*	*1·4 to 1·5*	*1·5 to 1·6*	*1·6 to 1·7*	greater than *1·7*
Calculated frequency	$1\frac{1}{2}$	$10\frac{1}{2}$	27	$45\frac{1}{2}$	$64\frac{1}{2}$	$78\frac{1}{2}$	87	88	$81\frac{1}{2}$	71	58	45	33	23	15	$9\frac{1}{2}$	$5\frac{1}{2}$	7
Observed frequency	2	14	$27\frac{1}{2}$	51	$64\frac{1}{2}$	91	$94\frac{1}{2}$	$68\frac{1}{2}$	$65\frac{1}{2}$	73	$48\frac{1}{2}$	$40\frac{1}{2}$	$42\frac{1}{2}$	20	$22\frac{1}{2}$	12	5	$7\frac{1}{2}$
Difference	$+\frac{1}{2}$	$+3\frac{1}{2}$	$+\frac{1}{2}$	$+5\frac{1}{2}$	—	$+12\frac{1}{2}$	$+7\frac{1}{2}$	$-19\frac{1}{2}$	-16	$+2$	$-9\frac{1}{2}$	$-4\frac{1}{2}$	$+9\frac{1}{2}$	-3	$+7\frac{1}{2}$	$+2\frac{1}{2}$	$-\frac{1}{2}$	$+\frac{1}{2}$

whence $\chi^2 = 21{\cdot}80$, $P = {\cdot}19$.

Calculated value of standard deviation 1 (± ·017)
Observed „ „ „ ·982
Difference = − ·018

Comparison of Fit. Theoretical Equation: $y = \frac{2}{\pi}\cos^4\theta, \quad z = \tan\theta$.

Scale of *z*	less than *−3·05*	*−3·05 to −2·05*	*−2·05 to −1·55*	*−1·55 to −1·05*	*−1·05 to −·75*	*−·75 to −·45*	*−·45 to −·15*	*−·15 to +·15*	*+·15 to +·45*	*+·45 to +·75*	*+·75 to +1·05*	*+1·05 to +1·55*	*+1·55 to +2·05*	*+2·05 to +3·05*	more than *+3·05*
Calculated frequency	5	$9\frac{1}{2}$	$13\frac{1}{2}$	$34\frac{1}{2}$	$44\frac{1}{2}$	$78\frac{1}{2}$	119	141	119	$78\frac{1}{2}$	$44\frac{1}{2}$	$34\frac{1}{2}$	$13\frac{1}{2}$	$9\frac{1}{2}$	5
Observed frequency	4	$15\frac{1}{2}$	18	$33\frac{1}{2}$	44	75	122	138	$120\frac{1}{2}$	71	$46\frac{1}{2}$	36	11	9	6
Difference	-1	$+6$	$+4\frac{1}{2}$	-1	$-\frac{1}{2}$	$-3\frac{1}{2}$	$+3$	-3	$+1\frac{1}{2}$	$-7\frac{1}{2}$	$+2$	$+1\frac{1}{2}$	$-2\frac{1}{2}$	$-\frac{1}{2}$	$+1$

whence $\chi^2 = 7{\cdot}39$, $P = {\cdot}92$.

A very close fit.

We see then that if the distribution is approximately normal our theory gives us a satisfactory measure of the certainty to be derived from a small sample in both the cases we have tested; but we have an indication that a fine grouping is of advantage. If the distribution is not normal, the mean and the standard deviation of a sample will be positively correlated, so that although both will have greater variability, yet they will tend to counteract each other, a mean deviating largely from the general mean tending to be divided by a larger standard deviation Consequently I believe that the tables at the end of the present paper may be used in estimating the degree of certainty arrived at by the mean of a few experiments, in the case of most laboratory or biological work where the distributions are as a rule of a 'cocked hat' type and so sufficiently nearly normal.

SECTION VII. *Tables of* $\frac{n-2}{n-3}\,\frac{n-4}{n-5}\cdots\left(\begin{matrix}\frac{3}{2}\cdot\frac{1}{2}\ n\text{ odd}\\ \frac{2}{1}\cdot\frac{1}{\pi}\ n\text{ even}\end{matrix}\right)\int_{-\frac{\pi}{2}}^{\tan^{-1}z}\cos^{n-2}\theta\,d\theta$

for values of n from 4 *to* 10 *inclusive.*

Together with $\frac{\sqrt{7}}{\sqrt{2\pi}}\int_{-\infty}^{x}e^{-\frac{7x^2}{2}}dx$ *for comparison when* $n=10$.

$z\left(=\frac{x}{s}\right)$	$n=4$	$n=5$	$n=6$	$n=7$	$n=8$	$n=9$	$n=10$	For comparison $\left(\frac{\sqrt{7}}{\sqrt{2\pi}}\int_{-\infty}^{x}e^{-\frac{7x^2}{2}}dx\right)$
·1	·5633	·5745	·5841	·5928	·6006	·60787	·61462	·60411
·2	·6241	·6458	·6634	·6798	·6936	·70705	·71846	·70159
·3	·6804	·7096	·7340	·7549	·7733	·78961	·80423	·78641
·4	·7309	·7657	·7939	·8175	·8376	·85465	·86970	·85520
·5	·7749	·8131	·8428	·8667	·8863	·90251	·91609	·90691
·6	·8125	·8518	·8813	·9040	·9218	·93600	·94732	·94375
·7	·8440	·8830	·9109	·9314	·9468	·95851	·96747	·96799
·8	·8701	·9076	·9332	·9512	·9640	·97328	·98007	·98253
·9	·8915	·9269	·9498	·9652	·9756	·98279	·98780	·99137
1·0	·9092	·9419	·9622	·9751	·9834	·98890	·99252	·99820
1·1	·9236	·9537	·9714	·9821	·9887	·99280	·99539	·99926
1·2	·9354	·9628	·9782	·9870	·9922	·99528	·99713	·99971
1·3	·9451	·9700	·9832	·9905	·9946	·99688	·99819	·99986
1·4	·9531	·9756	·9870	·9930	·9962	·99791	·99885	·99989
1·5	·9598	·9800	·9899	·9948	·9973	·99859	·99926	·99999
1·6	·9653	·9836	·9920	·9961	·9981	·99903	·99951	
1·7	·9699	·9864	·9937	·9970	·9986	·99933	·99968	
1·8	·9737	·9886	·9950	·9977	·9990	·99953	·99978	
1·9	·9770	·9904	·9959	·9983	·9992	·99967	·99985	
2·0	·9797	·9919	·9967	·9986	·9994	·99976	·99990	
2·1	·9821	·9931	·9973	·9989	·9996	·99983	·99993	
2·2	·9841	·9941	·9978	·9992	·9997	·99987	·99995	
2·3	·9858	·9950	·9982	·9993	·9998	·99991	·99996	
2·4	·9873	·9957	·9985	·9995	·9998	·99993	·99997	
2·5	·9886	·9963	·9987	·9996	·9998	·99995	·99998	
2·6	·9898	·9967	·9989	·9996	·9999	·99996	·99999	
2·7	·9908	·9972	·9991	·9997	·9999	·99997	·99999	
2·8	·9916	·9975	·9992	·9998	·9999	·99998	·99999	
2·9	·9924	·9978	·9993	·9998	·9999	·99998	·99999	
3·0	·9931	·9981	·9994	·9998	—	·99999	—	—

SECTION VIII. *Explanation of Tables.*

The tables give the probability that the value of the mean, measured from the mean of the population, in terms of the standard deviation of the sample, will lie between $-\infty$ and z. Thus, to take the table for samples of six, the probability of the mean of the population lying between $-\infty$ and once the standard deviation of the sample is ·9622 or the odds are about 24 to 1 that the mean of the population lies between these limits.

The probability is therefore ·0378 that it is greater than once the standard deviation and ·0756 that it lies outside $\pm 1{\cdot}0$ times the standard deviation.

SECTION IX. *Illustrations of Method.*

Illustration I. As an instance of the kind of use which may be made of the tables, I take the following figures from a table by A. R. Cushny and A. R. Peebles in the *Journal of Physiology* for 1904, showing the different effects of the optical isomers of hyoscyamine hydrobromide in producing sleep. The sleep of 10 patients was measured without hypnotic and after treatment (1) with D. hyoscyamine hydrobromide, (2) with L. hyoscyamine hydrobromide. The average number of hours' sleep gained by the use of the drug is tabulated below.

The conclusion arrived at was that in the usual dose 2 was, but 1 was not, of value as a soporific.

Additional hours' sleep gained by the use of hyoscyamine hydrobromide.

Patient	1 (Dextro-)	2 (Laevo-)	Difference (2–1)
1.	+ ·7	+ 1·9	+ 1·2
2.	− 1·6	+ ·8	+ 2·4
3.	− ·2	+ 1·1	+ 1·3
4.	− 1·2	+ ·1	+ 1·3
5.	− 1	− ·1	0
6.	+ 3·4	+ 4·4	+ 1·0
7.	+ 3·7	+ 5·5	+ 1·8
8.	+ ·8	+ 1·6	+ ·8
9.	0	+ 4·6	+ 4·6
10.	+ 2·0	+ 3·4	+ 1·4
	Mean + ·75	Mean + 2·33	Mean + 1·58
	S. D. 1·70	S. D. 1·90	S. D. 1·17

First let us see what is the probability that 1 will on the average give increase of sleep; i.e. what is the chance that the mean of the population of which these experiments are a sample is positive. $\frac{+\cdot 75}{1\cdot 70} = \cdot 44$ and looking out $z = \cdot 44$ in the table for ten experiment we find by interpolating between ·8697 and ·9161 that ·44 corresponds to ·8873, or the odds are ·887 to ·113 that the mean is positive.

That is about 8 to 1 and would correspond in the normal curve to about 1·8 times the probable error. It is then very likely that 1 gives an increase of sleep, but would occasion no surprise if the results were reversed by further experiments.

If now we consider the chance that 2 is actually a soporific we have the mean increase of sleep $= \frac{2\cdot33}{1\cdot90}$ or 1·23 times the S.D. From the table the probability corresponding to this is ·9974, i.e. the odds are nearly 400 to 1 that such is the case. This corresponds to about 4·15 times the probable error in the normal curve. But I take it the real point of the authors was that 2 is better than 1. This we must test by making a new series, subtracting 1 from 2. The mean value of this series is + 1·58 while the S.D. is 1·17, the mean value being + 1·35 times the S.D. From the table the probability is ·9985 or the odds are about 666 to 1 that 2 is the better soporific. The low value of the S.D. is probably due to the different drugs reacting similarly on the same patient, so that there is correlation between the results.

Of course odds of this kind make it almost certain that 2 is the better soporific, and in practical life such a high probability is in most matters considered as a certainty.

Illustration II. Cases where the tables will be useful are not uncommon in agricultural work, and they would be more numerous if the advantages of being able to apply statistical reasoning were borne in mind when planning the experiments. I take the following instances from the accounts of the Woburn farming experiments published yearly by Dr Voelcker in the *Journal of the Agricultural Society*.

A short series of pot culture experiments were conducted in order to determine the causes which lead to the production of Hard (glutinous) wheat or Soft (starchy) wheat. In three successive years a bulk of seed corn of one variety was picked over by hand and two samples were selected, one consisting of "hard" grains and the other of "soft." Some of each of these were planted in both heavy and light soil and the resulting crops were weighed and examined for hard and soft corn.

The conclusion drawn was that the effect of selecting the seed was negligible compared with the influence of the soil.

This conclusion was thoroughly justified, the heavy soil producing in each case nearly 100 per cent. of hard corn, but still the effect of selecting the seed could just be traced in each year.

But a curious point, to which Dr Voelcker draws attention in the 2nd year's report, is that the soft seeds produced the higher yield of both corn and straw. In view of the well-known fact that the *varieties* which have a high yield tend to produce soft corn, it is interesting to see how much evidence the experiments afford as to the correlation between softness and fertility in the same *variety*.

Further, Mr Hooker* has shown that the yield of wheat in one year is largely determined by the weather during the preceding harvest. Dr Voelcker's results may afford a clue as to the way in which the seed is affected, and would almost justify the selection of particular soils for growing seed wheat†.

The figures are as follows, the yields being expressed in grammes per pot.

Year	1899		1900		1901		Average	Standard Deviation	z
Soil	Light	Heavy	Light	Heavy	Light	Heavy			
Yield of corn from soft seed	7·85	8·89	14·81	13·55	7·48	15·39	11·328		
,, ,, hard ,,	7·27	8·32	13·81	13·36	7·97	13·13	10·643		
Difference	+ ·58	+ ·57	+1·00	+ ·19	− ·49	+2·26	+ ·685	·778	·88
Yield of straw from soft seed	12·81	12·87	22·22	20·21	13·97	22·57	17·442		
,, ,, hard ,,	10·71	12·48	21·64	20·26	11·71	18·96	15·927		
Difference	+2·10	+ ·39	+ ·78	− ·05	+2·66	+3·61	+1·515	1·261	1·20

If we wish to find the odds that soft seed will give a better yield of corn on the average, we divide the average difference by the standard deviation, giving us

$$z = {\cdot}88.$$

Looking this up in the table for $n = 6$ we find $p = {\cdot}9465$ or the odds are ·9465 : 535, about 18 : 1.

Similarly for straw $z = 1{\cdot}20$, $p = {\cdot}9782$, and the odds about 45 : 1.

In order to see whether such odds are sufficient for a practical man to draw a definite conclusion, I take another set of experiments in which Dr Voelcker compares the effects of different artificial manures used with potatoes on the large scale.

The figures represent the difference between the crops grown with the use of sulphate of potash and kainit respectively in both 1904 and 1905.

		cwt.	qr.	lb.			ton	cwt.	qr.	lb.	
1904	+	10	3	20	:	+	1	10	1	26	(two experiments in each year).
1905	+	6	0	3	:	+		13	2	8	

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* *Journal of Royal Statistical Society*, 1907.

† And perhaps a few experiments to see whether there is a correlation between yield and 'mellowness' in barley.

The average gain by the use of sulphate of potash was 15·25 cwt. and the S.D. 9 cwt., whence, if we want the odds that the conclusion given below is right, $z = 1{\cdot}7$ corresponding, when $n = 4$, to $p = {\cdot}9698$ or odds of 32 : 1; this is midway between the odds in the former example. Dr Voelcker says 'It may now fairly be concluded that for the potato crop on light land 1 cwt. per acre of sulphate of potash is a better dressing than kainit.'

As an example of how the tables should be used with caution, I take the following pot culture experiments to test whether it made any difference whether large or small seeds were sown.

Illustration III. In 1899 and in 1903 "head corn" and "tail corn" were taken from the same bulks of barley and sown in pots. The yields in grammes were as follows:

	1899	1903
Large seed	13·9	7·3
Small seed	14·4	8·7
	+ ·5	+ ·6

The average gain is thus ·55 and the S.D. ·05, giving $z = 11$. Now the table for $n = 2$ is not given, but if we look up the angle whose tangent is 11 in Chambers' tables,

$$p = \frac{\tan^{-1} 11}{180^\circ} + {\cdot}5 = \frac{84^\circ\ 47'}{180^\circ} + {\cdot}5 = {\cdot}971,$$

so that the odds are about 33 : 1 that small corn gives a better yield than large. These odds are those which would be laid, and laid rightly, by a man whose only knowledge of the matter was contained in the two experiments. Anyone conversant with pot culture would however know that the difference between the two results would generally be greater and would correspondingly moderate the certainty of his conclusion. In point of fact a large scale experiment confirmed the result, the small corn yielding about 15 per cent. more than the large.

I will conclude with an example which comes beyond the range of the tables, there being eleven experiments.

To test whether it is of advantage to kiln-dry barley seed before sowing, seven varieties of barley were sown (both kiln-dried and not kiln-dried) in 1899 and four in 1900; the results are given in the table.

It will be noticed that the kiln-dried seed gave on an average the larger yield of corn and straw, but that the quality was almost always inferior. At first sight this might be supposed to be due to superior germinating power in the kiln-dried seed, but my farming friends tell me that the effect of this would be that the kiln-dried seed would produce the better quality barley. Dr Voelcker draws the conclusion "In such seasons as 1899 and 1900 there is no particular advantage in kiln-drying before sowing." Our examination completely justifies this and adds "and the quality of the resulting barley is inferior though the yield may be greater."

	lbs. head corn per acre			Price of head corn in shillings per quarter			cwts. straw per acre			Value of crop per acre in shillings *		
	N. K. D.	K. D.	Diff.	N. K. D.	K. D.	Diff.	N. K. D.	K. D.	Diff.	N. K. D.	K. D.	Diff.
1899	1903	2009	+106	26½	26½	0	19¼	25	+5¾	140½	152	+11½
	1935	1915	− 20	28	26½	−1½	22¾	24	+1¼	152½	145	−7½
	1910	2011	+101	29½	28½	−1	23	24	+1	158½	161	+2½
	2496	2463	− 33	30	29	−1	23	28	+5	204½	199½	−5
	2108	2180	+ 72	27½	27	−½	22½	22½	0	162	164	+2
	1961	1925	− 36	26	26	0	19¾	19½	−¼	142	139½	−2½
	2060	2122	+ 62	29	26	−3	24½	22¼	−2¼	168	155	−13
1900	1444	1482	+ 38	29½	28½	−1	15½	16	+½	118	117½	−½
	1612	1542	− 70	28½	28	−½	18	17¼	−¾	128½	121	−7½
	1316	1443	+127	30	29	−1	14¼	15¾	+1½	109½	116½	+7
	1511	1535	+ 24	28½	28	−½	17	17¼	+¼	120	120½	+½
Average	1841·5	1875·2	+33·7	28·45	27·55	−·91	19·95	21·05	+1·10	145·82	144·68	+1·14
Standard Deviation	—	—	63·1	—	—	·79	—	—	2·25	—	—	6·67
Standard Deviation ÷√8	—	—	22·3	—	—	·28	—	—	·80	—	—	2·40

* Straw being valued at 15*s*. per ton.

In this case I propose to use the approximation given by the normal curve with standard deviation $\frac{s}{\sqrt{(n-3)}}$ and therefore use Sheppard's tables, looking up the difference divided by $\frac{s}{\sqrt{8}}$. The probability in the case of yield of corn per acre is given by looking up $\frac{33{\cdot}7}{22{\cdot}3} = 1{\cdot}51$ in Sheppard's tables. This gives $p = {\cdot}934$, or the odds are about 14 : 1 that kiln-dried corn gives the higher yield.

Similarly $\frac{{\cdot}91}{{\cdot}28} = 3{\cdot}25$, corresponding to $p = {\cdot}9994$,* so that the odds are very great that kiln-dried seed gives barley of a worse quality than seed which has not been kiln-dried.

Similarly it is about 11 to 1 that kiln-dried seed gives more straw and about 2 : 1 that the total value of the crop is less with kiln-dried seed.

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* As pointed out in Section V. the normal curve gives too large a value for p when the probability is large. I find the true value in this case to be $p = {\cdot}9976$. It matters little however to a conclusion of this kind whether the odds in its favour are 1,660 : 1 or merely 416 : 1.

SECTION X.

Conclusions.

I. A curve has been found representing the frequency distribution of standard deviations of samples drawn from a normal population.

II. A curve has been found representing the frequency distribution of values of the means of such samples, when these values are measured from the mean of the population in terms of the standard deviation of the sample.

III. It has been shown that this curve represents the facts fairly well even when the distribution of the population is not strictly normal.

IV. Tables are given by which it can be judged whether a series of experiments, however short, have given a result which conforms to any required standard of accuracy or whether it is necessary to continue the investigation.

Finally I should like to express my thanks to Professor Karl Pearson, without whose constant advice and criticism this paper could not have been written.

SPLIT-HAND AND SPLIT-FOOT DEFORMITIES, THEIR TYPES, ORIGIN, AND TRANSMISSION*.

By THOMAS LEWIS, D.Sc., M.D. etc., and DENNIS EMBLETON, B.A., M.R.C.S. etc.

(*From University College Hospital.*)

CONTENTS.

	PAGE
Introductory	26
Detailed Account of the Deformities of the "G" Family	27
Types of Split-foot, their Terminology, and the Nature of the Cross-bones	36
Origin and Transmission of the Deformity	43
(*a*) General	43
(*b*) Maternal impressions	44
(*c*) Origin in an acquired lesion (extrauterine)	44
(*d*) Arrests of development	45
(*e*) Atavism	45
(*f*) Origin as a result of intrauterine conditions	46
(*g*) Origin as a "sport"	48
(*h*) Transmission of "Hereditary Split-foot," its stability, and the relation of its mode of transmission to Mendelism	50
Summary and Chief Conclusions	56
Bibliography	56
Explanation of Plates	58

Introductory.

THE deformity presented by the family described in this communication is one of exceptional interest and has so far received little attention. Accounts of it, of a brief and scattered nature, sometimes with figures, are to be found in the works of many of the well-known teratologists, such as Geoffroy Saint-Hilaire, Ammon, Förster and Otto.

In a Japanese temple an image of it has assumed, states Perthes (p. 136), the dignity of a god; a cloven hoofed deity.

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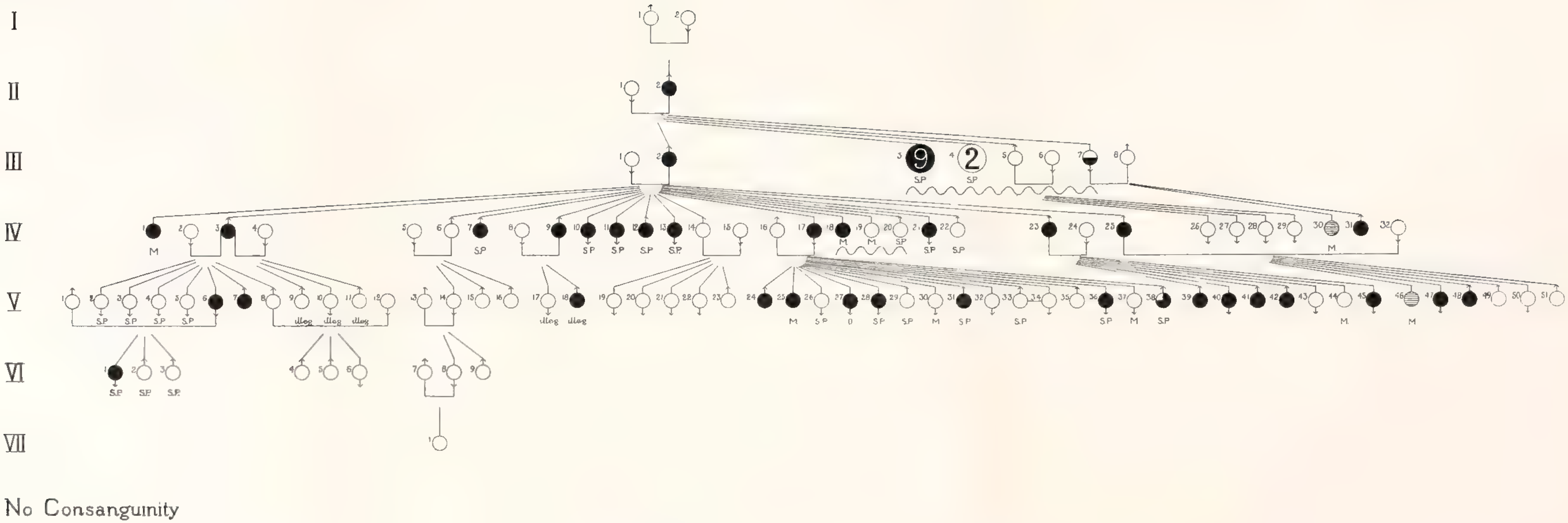
* To this paper, written in November 1907, a short postscript, dated March 2nd, 1908, has been added. It will be found in the Miscellanea of this number.


I
II
III
IV
V
VI
VII
No Consanguinity
S.P
M
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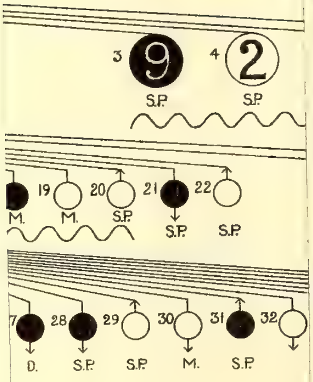
0

FIG. (I). GENEALOGICAL TREE OF THE "G" FAMILY.


3
9
S.P.
4
2
S.P.
M.
19
M.
20
S.P.
21
S.P.
22
S.P.
7
D.
28
S.P.
29
S.P.
30
M.
31
S.P.
32

THE "G" FAMILY.

The first collected description of cases which we have found is that by Kümmel. This author discusses the nature of "Spalt-Hand und Spalt-Fuss" at some length, but his account loses much of its value in that all types are indiscriminately mixed, and the question of heredity receives no attention. In a later monograph Perthes has brought a number of cases together on the same basis.

From the many varieties of split-hand and split-foot, one stands out prominently, and of this our "G" family presents notable examples. This type is characterised by its marked tendency to transmission, and by other features.

Including our family we have collected in all over 180 individual cases of the deformity, and have studied the details or detailed records of a large number of these*. We are therefore in a position to give a general sketch of the condition and its relation to general problems of heredity.

In searching the records for previously reported examples we have been fortunate in finding two earlier accounts of this remarkable family†, which contains more deformed members than any yet recorded. In 1886, before the introduction of "X rays," Anderson gave a description of it. A further brief summary was written by Tubby thirteen years ago. The addition of new members to the genealogical tree entitles the family to further consideration.

We must express our gratitude to Dr Higham Cooper of University College Hospital and to Dr Edward Shenton of Guy's for the invaluable aid they have given us in the screening and skiagraphy of the individual subjects of this investigation.

Detailed Account of the Deformities of the "G" Family.

Observations have been for the most part confined to the bones of the hands and feet. Other deformities have been inquired into, and no such defects are known to exist. A complete examination of the family from this point of view has not been undertaken.

A thorough investigation of the soft parts of the hands and feet has also been neglected on account of the number of the deformed. From the observations made the following brief statements of the chief features may be made. The skin follows the lines of the underlying bones and tissues (Figs. 4, 5), and in no case has evidence of scarring been found, such as might suggest intrauterine injuries. The nails correspond in number almost without exception to the number of the terminal phalanges. When two fingers are closely syndactylised the nails are also united.

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* Since this paper has been in the press, several other families showing the same deformity and living in London have been heard of, and other similar families in different parts of the country. An example which is typical is figured in Cruveilhier's well known "Atlas d'Anatomie pathologique, etc." The deformity appears to be a by no means uncommon one.

† Space does not permit of our giving the proofs that the three families are identical, but we are depositing private evidence with additional notes and radiograms, which future observers will find of value, in the library of the College of Surgeons.

The hands are curiously and variously misshapen and over the abnormal bony points thick masses of subcutaneous tissue are placed, which are frequently conica in appearance and as a rule situated towards the palmar aspect. These prominences are utilised in conjunction with the remaining finger or fingers for gripping. When a cross bone exists, the hand is far broader than might be expected from the number of metacarpals present. In no case is there any abnormality in the arrangement of the arteries as far as the wrist, and the tendons present correspond, so far as can be observed, to the presence of the metacarpals and phalanges to which they are normally attached. There are often contractures of the remaining fingers, so that they are flexed and drawn towards the middle of the hand. The contractures are dependent on the constitution and arrangement of the deeper structures and not upon the condition of the skin.

Each foot consists of two toes separated by a deep cleft. In exceptional cases there may be more than one complete toe in that portion of the foot bounding the outer side of this cleft, as evidenced by a double toe nail and longitudinal furrowing of the skin, but they are in no case separate. The cleft is always deep, and may have a length of four inches. As a rule it is two and a half to three and a half inches in the adult foot. The toes are widely apart at their centres, but are generally bent claw-wise at their extremities*. This separation of the toes gives the foot an unusual breadth in spite of the absence of metatarsals, a breadth which may amount to eight inches, or more. As a rule the inner border of the cleft runs parallel to the inner border of the foot for the greater part of its course and ends in furrows on the dorsum and sole of the foot. The outer border of the cleft is moulded over the remains of the metatarsal bones when these are present and is in consequence more irregular. On account of the inbending of the toe extremities to the middle line the foot is usually shortened. The tendons of the foot are arranged, like those of the hand, in conformity with the underlying bones; they are complete when the toes are present, and run to the ends of shortened digits.

The functional capacity of both hands and feet is great. The affected persons perform work which requires skilful manipulation. The needlework of some of the females is good; the handwriting of many is excellent. One individual is a boot-maker, two others drive cabs, none find difficulty in clothing themselves and most do so with extraordinary rapidity, even to the lacing of boots. The gait is normal; the toes are often opposible, more especially in the young, and frequently with considerable power and also delicacy. It is said of one that he is able in this way to lift pins from the floor with his feet. Nothing is more astonishing than the accurate and coordinate manner in which most of the functions of the normal hands and feet are carried out by parts so grossly deformed†. As to the muscular structures which subserve these functions we can say little, as no opportunity of dissection has offered itself, but details may be gleaned from the few dissections figured by Otto, and from those reported by Schäfer.

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* There is no evidence that this is produced by boot pressure, for it occurs in the younger subjects and has been observed in the new born. There is every possibility of its having been acquired *in utero*.

† The majority of those reporting this deformity express their surprise at the mobility of the malformed extremities.

In the following account of the defective conditions of the bones of the hands or feet the successive generations will be taken and the members of each generation described as they occur from left to right in the genealogical tree which has been given (Plate I, Fig. 1)*. In each case the source of information is stated, with the initials and where possible the dates of the birth and death of the individual. For the sake of brevity only those bones are described *which are present.* It must be understood that this applies rigidly unless it is otherwise expressly stated. The carpus which is omitted has in no case shown defect. The astragalus, os calcis and navicular bone have likewise never given evidence of affection. With regard to the last row of tarsal bones it must be said that we are often unable to render an exact account of it, and this for two reasons. First the frequent difficulty of identifying the bones by screening, and secondly the fact that when the cleft is deep considerable derangement of the tarsus occurs with separation of the bones and welding of them. The account is consequently confined so far as these are concerned to the chief points of interest observed. The omission of mention of carpal and tarsal bones must consequently not be interpreted in the light of our previous remark.

Generation I (I, 1 and 2)†. The parents of the first deformed individual are definitely stated by Anderson to have been normal. Enquiries from members of the family now living fully confirm this statement. They are said to have lived in Scotland‡.

Generation II, 2. Anderson states that J. G. was an only child, born in 1793 and dying in 1871. The descendants confirm this. The Brentford records show the dates to be correct. Several of the family now living knew him and give details of his deformity. The accounts correspond fairly well. The deformity of the feet was of the usual type but the feet were exceptionally broad. The hands, both grossly deformed, are stated to have had many fingers, including the thumbs.

Generation III. (III, 2.) J. H. G. (1825–1890). His children are unanimous in stating that he had one finger on each hand and two toes on each foot.

(III, 3 and 4.) For these two groups we are mainly indebted to Anderson, who states that all the children died in childhood. The family know very little of them, and the accounts from different members fail to correspond. Unfortunately the Brentford records go back to 1837 only, and the birth certificate of one W. G. born in 1838 is alone obtainable. We have therefore to rely on Anderson, and in consideration of the accuracy of his account in most points of importance in which we have been able to check it, we have little hesitation in accepting these figures. No information of the individual deformities is obtainable.

(III, 7.) M. P. (1832, still alive, married). This individual, who is 75 years of age, is feeble minded; visits to her abode have been without success, as both she and her friends steadily refuse an interview. Her son's account agrees with that of Anderson. There is deformity of the feet only; each of these bears two digits.

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* For description, see Explanation of Plates, p. 58.

† The bracketed figures refer throughout to the generation and number in the tree, Fig. 1.

‡ It must be stated that we have recently heard from Professor Pearson of the existence some seventy years ago of a Scotch family presenting "Lobster claw" deformity, said to date back to the seventeenth century.

Generation IV. (IV, 1, 18 and 19.) M. A. (IV, 17), who has lived with her mother for the last 17 years, states emphatically that there were three miscarriages in her generation. The first of these was deformed (IV, 1); and of the others, whose position in the family is uncertain, one was deformed the other undeformed (IV, 18 and 19).

(IV, 3.) H. C. G. (1845, still living, widower). Right handed. All four extremities screened. Anderson makes no mention of this man (cp. IV, 9 who also had illegitimate children).

Right hand. This is perfect with the exception that there is partial syndactyly of the 4th and 5th digits, and the terminal phalanx of the thumb is bent inwards.

Left hand. The last four fingers are normal. The 1st metacarpal is broad and its distal end is double. The inner facet bears a digit composed of three phalanges. The outer bears a small nodule of bone, the remains of an amputated digit which the man states was as long as its neighbour.

Right foot. The 4th and 5th toes have a normal complement of bones and are syndactylised throughout. The first toe shows no loss of bone. A deep cleft occupies the position of the absent 2nd toe. Between the cleft and the 4th toe lies the metatarsal of the 3rd toe, which has no phalanges. The cleft runs into the tarsus and the middle cuneiform appears to be absent.

Left foot. This is precisely similar to the right, but that it misses the terminal phalanx of the 4th toe.

(IV, 7.) Of this child we have no further information than that it was deformed and died in childhood; it is referred to by Anderson.

(IV, 9.) W. G. (approximately, 1852–1883). The hands and feet are stated by M. A. (IV, 17) to have been similar to those of her son W. H. A. (V, 24). Anderson makes no mention of this child, but the family have always been very reticent about him, as he had illegitimate children.

(IV, 10–13.) A. G. (approx. 1854–?), Ph. G. (1855–?). J. P. G. (1857–?), A. M. G. (1858–?). These four children are with one exception (IV, 10), mentioned by Anderson, and are said by him to have been deformed and to have died in childhood. Our enquiries make it probable that there were four deformed children lost at an early age, and the place of A. G. is taken in Anderson's account by a deformed son who died. No reliable details of the deformities are obtainable, apart from the fact that as usual all four extremities were affected.

(IV, 17.) M. A. (1861, still bearing children). Left handed. Skiagrams of all four extremities.

Right hand, Fig. 11. The thumb and 2nd finger are represented by the base of the 2nd metacarpal only. The 3rd metacarpal is normal, the 4th and 5th thickened*. From the apex of the 4th to the metacarpo-phalangeal articulation of the 5th a cross-bone extends, making a triple articulation from which a complete set of thickened phalanges arise.

Left hand, Fig. 10. The base of the 1st metacarpal is represented by a small nodule of bone. The 2nd metacarpal is thin at its distal end, the other three metacarpals are present. Between the extremities of the 3rd and 4th is a small bone articulating with the head of the 3rd and the cross-bone; it is the only representative of the phalanges of the outer three fingers. The cross-bone extends from the apex of the 4th metacarpal to the short 1st phalanx of the 5th. From the last articulation spring the terminal phalanges of two fingers, united throughout by bone. The corresponding nail is double.

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* In the hands where the affection is mainly preaxial the postaxial metacarpals are always thickened, and in the following mention of it will be omitted.

Right foot. There are the usual inner and outer toes separated by a deep cleft. The outer metatarsal misses one phalanx, and those of the inner are united. At the bottom of the cleft is one piece of bone presumably the welded bases of the 2nd and 3rd metatarsals. The broad base of the 5th metatarsal indicates a fusion of it with the base of the 4th.

Left foot, Fig. 16. There are two toes only. The outer has an enormously thickened metatarsal articulating with the whole anterior surface of the cuboid. It bears three phalanges of which the last two are united. The inner metatarsal is also thick and bears two united phalanges. Its base articulates with the inner and middle cuneiforms. To the outer side of the cleft is a small piece of bone presumably the base of the 3rd metatarsal.

(IV, 20–22.) G. G., A. H. G., and Al. H. G. (born 1862, 1863 and 1865), are mentioned by Anderson, and our account confirms his; the three children died in childhood. No details of the deformity of A. H. G. are obtainable.

(IV, 23.) E. G. (approx. 1867, living, widower). Right handed. Skiagrams of all extremities.

Right hand, Fig. 23. All the metacarpals are present, the distal end of the 2nd is thin. The 1st, 4th and 5th have complete phalanges. The 3rd has a short 1st phalanx. The phalanges of the outer three fingers are united by skin.

Left hand, Fig. 22. This is similar except that the 2nd metacarpal is more fully developed.

Right foot. It is not possible to identify all the bones. On the inner side of the cleft is a large metatarsal (the 1st) bearing two phalanges. On the outer side two very heavy metatarsals occupying the articulatory positions of the 3rd, 4th and 5th. From the inner of these two, which articulate at their ends, springs a set of three phalanges.

Left foot. This is precisely similar.

(IV, 25.) I. G. (approx. 1869, living, married). Right handed. Screening of all four extremities.

Right hand. A small portion of the base of the 1st metacarpal is present. The other four are perfect. The 3rd bears the base of a 1st phalanx. The 4th bears the greater part of a 1st phalanx. The 5th has two complete phalanges, which are united to that of the 4th by skin.

Left hand. The thumb is not represented. The other metacarpals are perfect. The 3rd has the proximal half of the 1st phalanx. On the 4th is one and on the 5th two complete phalanges.

Right foot. Only two toes are present. The inner is composed of the complete 1st digit with the remains of the metatarsal of the 2nd united to its base. The outer toe consists of the complete 5th digit and the 4th metatarsal and its single 1st phalanx. A deep cleft runs as usual between the two toes and disturbs the arrangement of the tarsus. There is a piece of bone united to the base of the 4th metatarsal which appears to be the base of the 3rd metatarsal.

Left foot. There are two toes only. The inner composed of the complete 1st digit having its phalanges united; the outer consisting of a complete 5th digit, the bones of which are much thickened. Between the 5th metatarsal and the usual cleft lies a compound bone composed apparently of the 4th metatarsal united with its 1st phalanx and the base of the 3rd metatarsal. There is derangement of the tarsus but the base of the 2nd metatarsal appears to be represented.

(IV, 30.) The son (IV, 31) of M. P. (III, 7) states that there was a miscarriage before he was born, but no information as to whether it had any deformity is obtainable.

(IV, 31.) E. P. (approx. 1872, living and about to marry). Right handed. All four extremities screened.

Right hand. The 1st and 2nd digits are entirely absent. The 3rd metacarpal bears a small nodule of bone. The 4th and 5th digits are complete and syndactylised by skin.

Left hand. This is similar, it has in addition a thin 2nd metacarpal.

The feet. These are alike. The usual deep cleft occurs at the 2nd toe. The 1st and 5th toes are alone present and are complete.

Generation V. (V, 6.) A. S. (1870, living, married). All extremities screened.

Right hand. The last three fingers are normal. The 2nd misses the terminal phalanx, and the proximal phalanges are thin. The 1st metacarpal is present and bears two short deformed phalanges. From its inner side and about ¾ of an inch from its end, a small movable piece of bone springs. This is the remains of an amputated digit. There appears to be slight movement in the shaft of the metacarpal at this point. The amputated digit originally traversed the palm of the hand.

Left hand. The metacarpal bone of the thumb is broad at its distal end and bears on its inner facet three phalanges. The outer facet is unoccupied, but a scar indicates the position from which an additional digit was removed. It is said to have consisted of two bones and to have been as long as its neighbour. The rest of the hand is normal.

Right foot. The cleft occupies the position of the 2nd toe which is absent with the middle cuneiform. On the inner side of it lies the 1st metatarsal with two united phalanges. On the outer side lie a complete 5th digit and the metatarsal of the 4th, the phalanges of the latter and the bones of the 3rd toe are absent.

Left foot. This is the same but for the absence of union of the phalanges of the 1st toe.

(V, 7.) H. G. (approx. 1872, living, unmarried). Right handed. All extremities screened.

Right hand. The 1st metacarpal is small and weak; it has an extra phalanx. The 2nd, 4th and 5th metacarpals have complete sets of phalanges. The 3rd metacarpal has one complete and one incomplete phalanx. There is no syndactyly.

Left hand. The thumb is composed of metacarpal only. The bones of fingers 2, 3 and 5 are perfect throughout. From the 4th metacarpal springs a phalanx which is bifid distally, each facet bearing a complete set of phalanges. These sets are united by skin to the neighbouring fingers 3 and 5, but are themselves distinct up to the level of the common 1st phalanx. There are thus three fingers. That containing phalanges from metacarpals 4 and 5 has a single, and that containing phalanges from metacarpals 3 and 4 a double nail.

Right foot. There are the 1st and 5th toes, thickened and separated by a deep cleft. To the outer side of the cleft is the remains of a 4th metatarsal.

Left foot. This is similar.

(V, 18.) The illegitimate son of W. G. (IV, 9). Date of birth not known. He is said to have died. His hands are reported to have been similar to those of I. G. (IV, 25). The feet having each two toes.

(V, 24.) W. H. A. (1882, living, single). Right handed. All extremities screened, and left hand skiagraphed.

Right hand. This is very deformed and the identification of the bones is not quite certain. The arrangement is probably as follows:—The thumb is represented by a small nodule only. The remaining metacarpals are all present but the outer two are closely united by bone throughout There is a wide gap between the 3rd and 4th. The united 4th and 5th bear a common double 1st phalanx, which in turn bears two short single phalanges, articulated end to end. From the metacarpo-phalangeal joint of the combined 4th and 5th fingers a cross-bar runs to the head of the 3rd metacarpal with which it articulates.

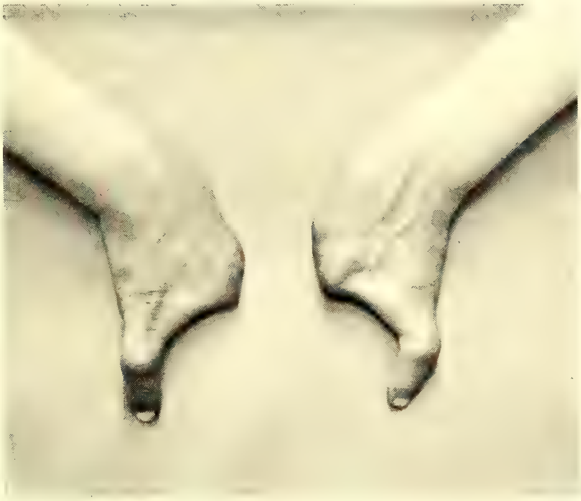

Fig. 4

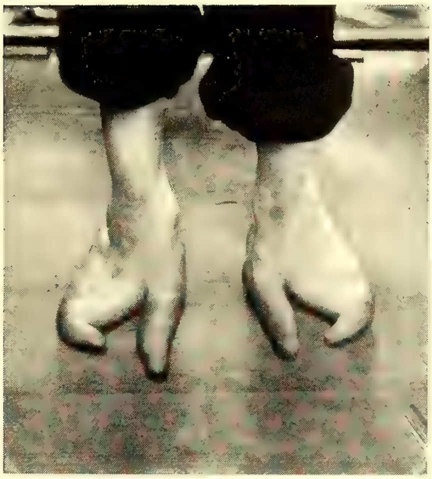

Fig. 5

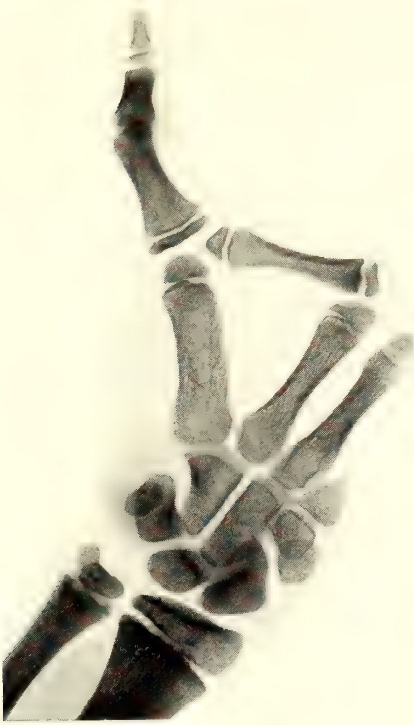

FIG. 6

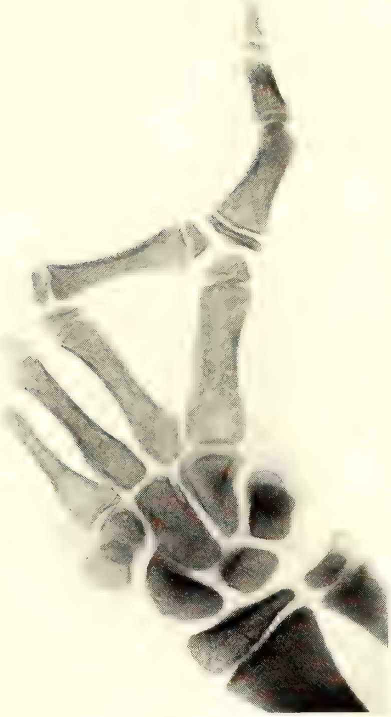

FIG. 7

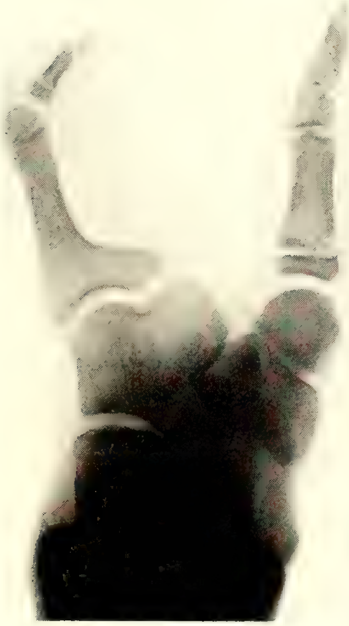

FIG. 8

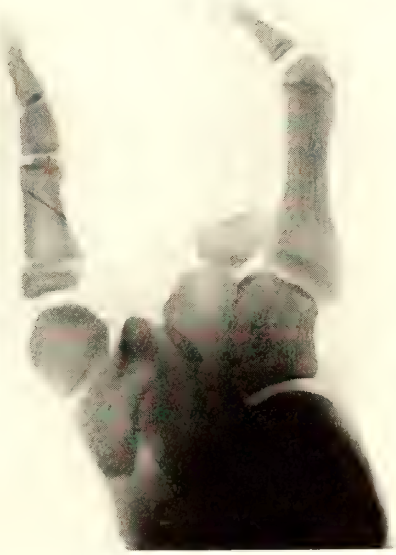

FIG. 9

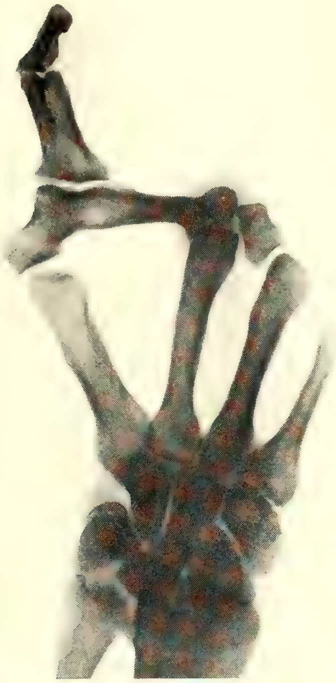

Fig. 10

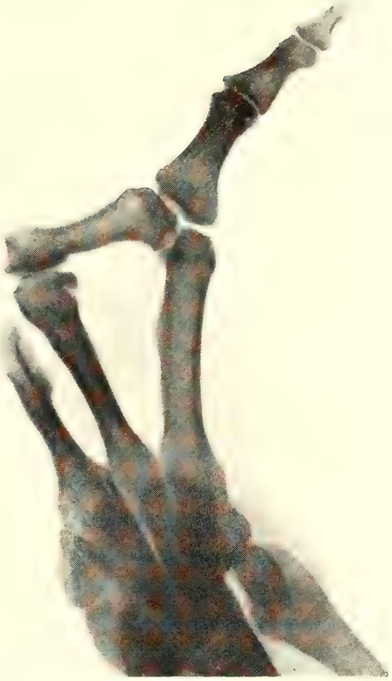

Fig. 11

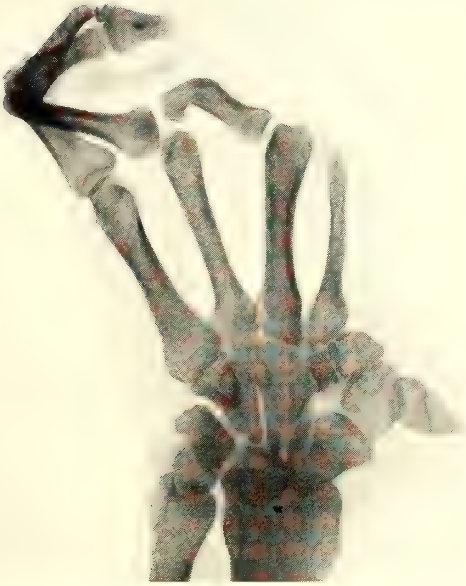

Fig. 12

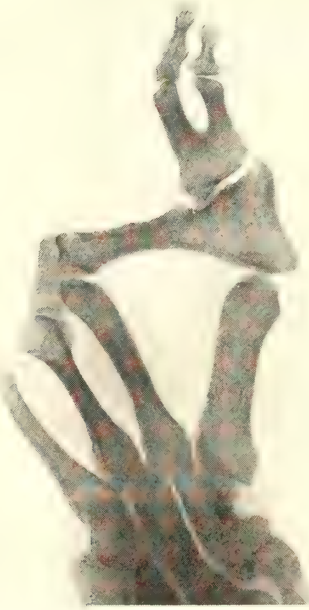

Fig. 13

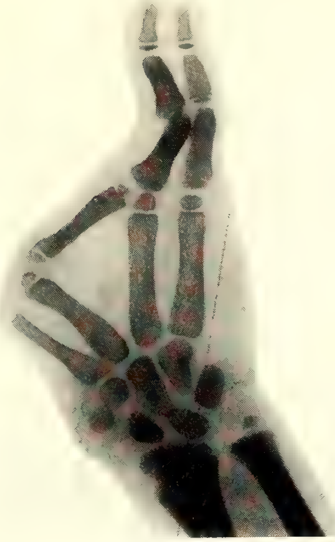

Fig. 14

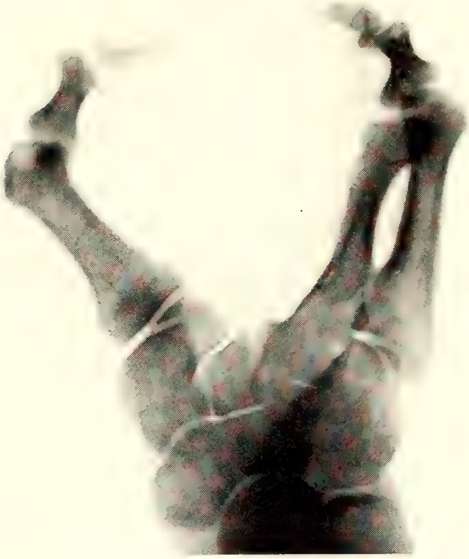

Fig. 15

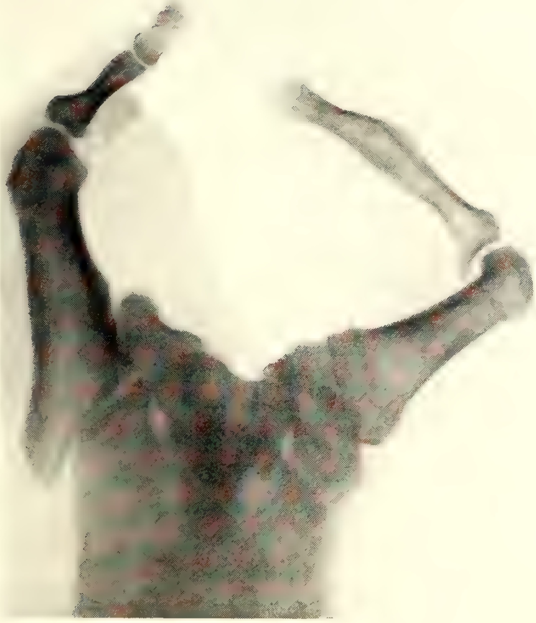

Fig. 16

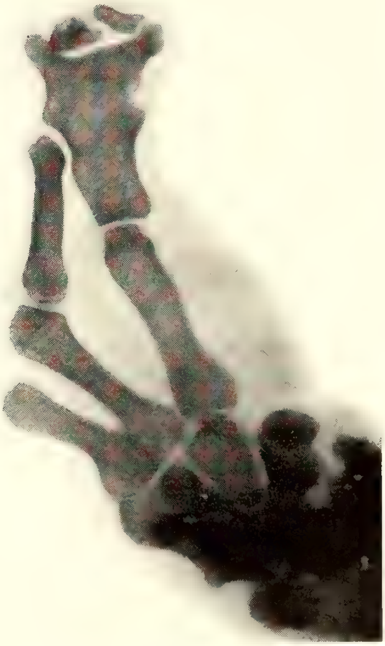

Fig. 17

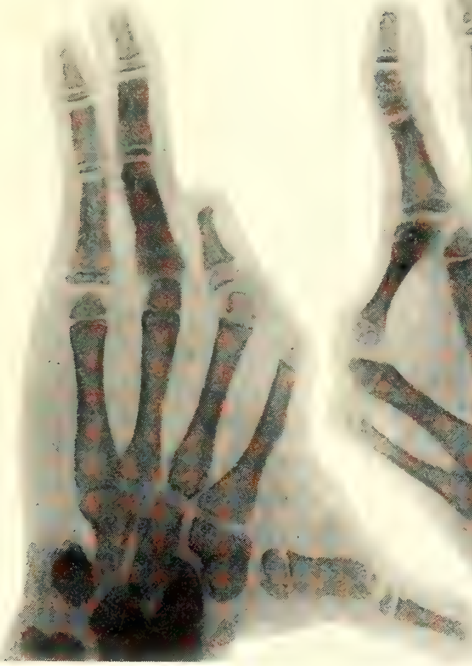

FIG. 18

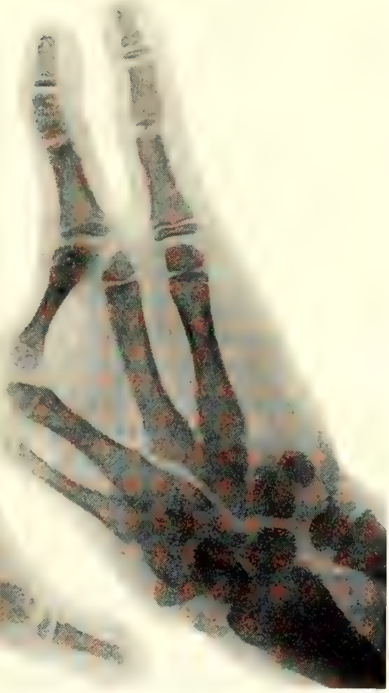

FIG. 19

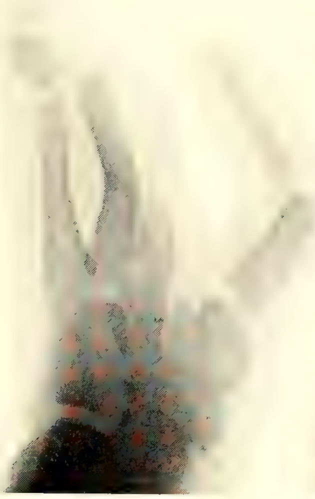

FIG. 20

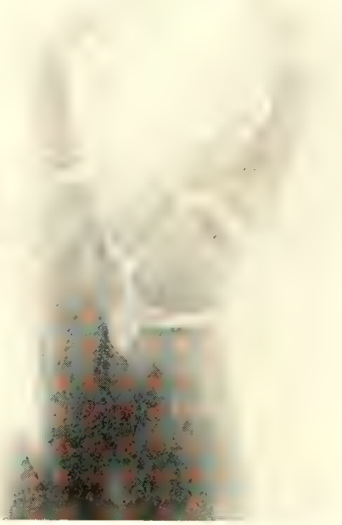

FIG. 21

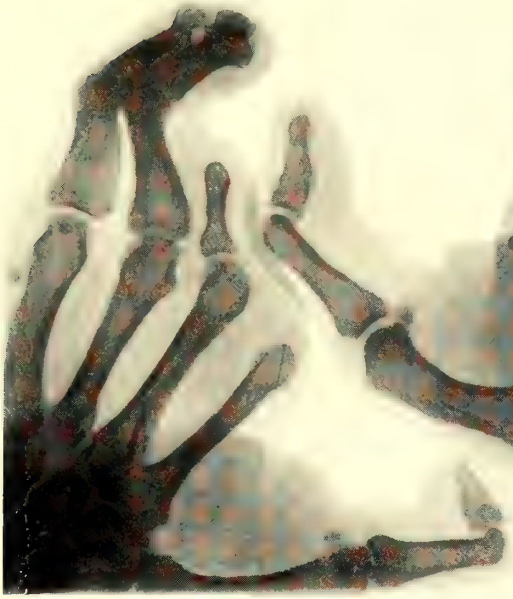

Fig. 22

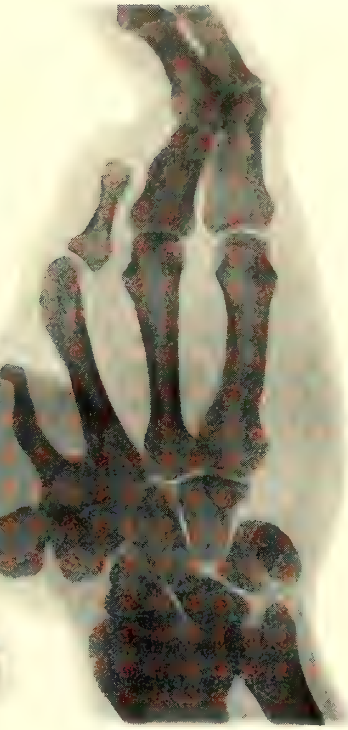

Fig. 23

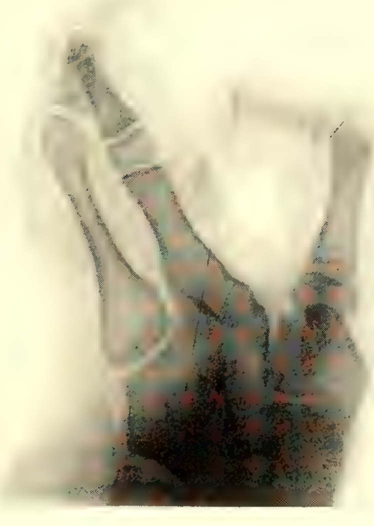

Fig. 24

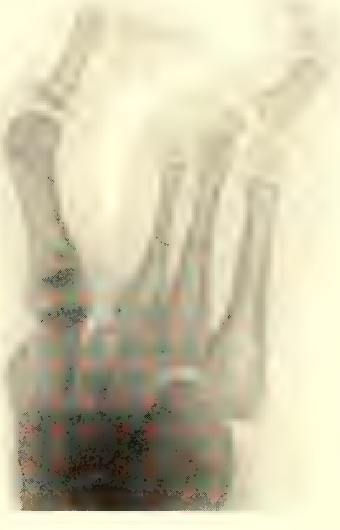

Fig. 25

Left hand. This is the most malformed of the series (Fig. 17). There are three heavy metacarpals articulating with the trapezium, os magnum and unciform bones. They probably represent the 3rd, 4th and 5th metacarpals. From the 4th springs a bone resembling a phalanx which articulates with the outer side of a welded mass of bone which itself springs from the head of the 5th metacarpal. The welded mass is 2 inches long and about 1 inch broad. It lies in the line of the metacarpal, from which it springs. At the free end of the mass are two terminal projections resembling short horns. The inner bears two small nodules of bone and a double nail. The outer has no nail. Between it and the inner are two small nodules of bone. There is thus evidence that the mass as a whole represents the portions of at least the inner three fingers.

The feet. There is one digit on each foot in the position of the 5th toe. Each bears three phalanges. The metatarsal at its base is thick and articulates with the whole of the anterior surface of the cuboid. The base of the 1st metatarsal is represented on both sides, and on the right probably the base of the 3rd also.

(V, 25.) Miscarriage, 4 months pregnancy. The mother states that the child had one finger and one toe on each limb.

(V, 27.) L. A. (1885, single, suffering from tuberculosis of the lungs). Right handed. Screening of all extremities.

Right hand. This is almost perfect but shows contractures, the thumb is small, the index finger is flexed. There is skin union of the 3rd and 4th fingers and slight bony union of the terminal phalanges. The bones are otherwise normal.

Left hand. The 1st metacarpal is surmounted by a small nodule of bone only. The 2nd metacarpal has one complete and a second incomplete phalanx. The remaining three fingers are normal. Between the 2nd and 3rd fingers is a small piece of bone about 1½ cm. long, thin and narrow. It is on a level with the 1st phalanges and has the shape of a diminutive phalanx.

Right foot. On the inner side of the cleft the 1st toe is complete. On the outer side the inner toe is complete and to its inner side is a mass of bone obviously representing the 3rd and 4th metatarsals.

Left foot. On the inner side of the cleft the 1st toe is complete. On the outer side the 5th toe has metatarsal only. The 4th metatarsal has one complete and one incomplete phalanx, it is united at its base with the remains of the 3rd metatarsal.

(V, 28.) H. A. (1887– approx. 1895). Tubby states that this child had two fingers on each hand and two toes on each foot.

(V, 31.) J. A. (approx. 1892–1897). We are indebted to St Thomas's Hospital for notes of this child*.

Right hand. The thumb is not represented. The 5th finger has a full complement of phalanges. The 2nd, 3rd and 4th metacarpals are poorly developed and have no phalanges.

Left hand. Much the same as the right, but has two sets of phalanges for 4th and 5th fingers.

Right foot. Great and little toes only, of which the metatarsals are alone perfect. The cleft extends to the articulation between the metatarsal and the internal cuneiform.

Left foot. The same as the right, but the great toe has the stump of a metatarsal only.

(V, 36.) M. A. (approx. 1902–1905). The mother states that there was the usual deformity of the feet, each having two toes. The hands are said to have had one finger each.

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* The notes are ward notes, there was no screening.

(V, 38.) J. A. (1906—1906). Screening of extremities. The child was born by the vertex, forceps were used and labour was prolonged. The after-birth was normal and there were no signs of adhesions or amputated digits. The post-mortem some months later was not obtainable.

Right hand. The five metacarpals were present though the 1st was small and bore no phalanges. The 2nd, 4th and 5th fingers had complete bones. The 3rd metacarpal had a phalanx double at its distal end and this in turn bore two complete sets of phalanges. The 2nd, 3rd and 4th fingers, namely four sets of phalanges, were united by skin (cp. Left hand of H. G. (V, 7)).

Left hand. This was normal.

The feet. The deformity was typical, the feet having each two toes, separated by wide clefts. The increased thickness of the 1st and 5th metatarsals and the general conformity of the foot to the type in other members of the family is of interest in that it indicates that little of the permanent adult deformity is due to use.

(V, 39.) E. W. G. (1886, living). Right handed. All extremities screened.

Right hand. Precisely similar to the left hand of R. E. G. which is figured (Fig. 7), except that its epiphyses are joined and that the 3rd metacarpal has no head.

Left hand. This is the same as the right but it has the head of the 3rd metacarpal.

The feet. The 1st and 5th toes are present with the full number of bones. The clefting is deep and the tarsus disturbed. There is welding of the remains of the 2nd and 4th metatarsals to the adjacent bones.

(V, 40.) E. M. G. (1888, living, single). Ambidextrous. Skiagraphy of all extremities.

Right hand, Fig. 13. There is no trace of the bones of the thumb. The remaining metacarpals are present. The 3rd bears a half phalanx. From the distal end of the 4th a large complex cross-bone extends to the head of the 5th, articulating with it and the conjoined bases of the two phalanges, presumably those of the 4th and 5th fingers. The united phalanges are separate at their distal ends, and bear, the inner one, the outer two phalanges, the latter united. We are inclined to the view that the 1st phalanx of the 5th finger is represented in the inner end of the cross-bone.

Left hand, Fig. 12. The base only of the 1st metacarpal is present. The 2nd metacarpal is thin and like the 1st bears no phalanges. The remaining metacarpals are present and of them the 4th and 5th have the full complement of phalanges, the two sets syndactylised by skin. From the head of the 3rd metacarpal a curved cross-bone proceeds to the metacarpo-phalangeal joint of the 4th finger.

Right foot, Fig. 15. On the inner side of the cleft is the 1st metatarsal bearing two phalanges. On the outer side are the 4th and 5th metatarsals, carrying between them two sets of united phalanges. The clefting is deep and causes some displacement and modification of the tarsus.

Left foot. This is practically identical; the middle cuneiform appears to be welded to the base of the 4th metatarsal.

(V, 41.) R. E. G. (1890, living). Right handed. Skiagraphy of all extremities.

Right hand, Figs. 4 and 7. The thumb is entirely absent. The 2nd metacarpal misses its distal end, the remainder are complete. The 5th finger is complete, the base of the 1st phalanx has a double articulation, the one facet for the metacarpal the other for the cross-bone which extends from this joint to the head of the 4th metacarpal.

Left hand, Figs. 4 and 6. This is similar, except that the 2nd metacarpal is represented by its base only.

Right foot, Figs. 5 and 9. There are the usual two toes and deep clefting. The outer toe has two phalanges, the inner two irregular ones. The base of the 4th metatarsal is represented.

The middle cuneiform appears to be absent, while the external seems to be welded to the cuboid.

Left foot, Figs. 5 and 8. This is similar, but the base of the 4th metatarsal is welded to that of the 5th.

(V, 42.) J. T. G. (1892, living). Right handed. Skiagraphy of all extremities.

Right hand, Fig. 19. The thumb is not represented. The four outer metacarpals are present, the 2nd being thin. The 4th and 5th have complete sets of phalanges. A cross-bone proceeds from the metacarpo-phalangeal joint of the 4th finger to the head of the 3rd metacarpal.

Left hand, Fig. 18. The five metacarpals are present. The 1st has one short phalanx. The 2nd none. The 3rd a half phalanx, replacing the cross-bone of the opposite side. The 4th and 5th have complete phalanges, syndactylised by skin.

Right foot, Fig. 25. All the metatarsal bones with the exception of the 2nd are present, the 2nd is replaced by the cleft. The 1st metatarsal bears two phalanges. The 4th and 5th have a common set.

Left foot, Fig. 24. To the inner side of the cleft lies a complete 1st toe. The 2nd is entirely replaced by the cleft. The base of the 3rd is welded to the 4th, and scarcely appears. The 4th is complete and has an irregular phalanx. The 5th has a complete set of phalanges.

(V, 45.) L. V. G. (1897, living). Right handed. Skiagrams of all extremities.

Right hand, Fig. 14. The thumb is not represented. The 2nd metacarpal has no distal epiphysis. The 4th and 5th have complete phalanges which show skin syndactyly. A cross-bone runs from the 4th metacarpo-phalangeal joint to the head of the 3rd complete metacarpal.

Left hand. This is similar but the 1st metacarpal has a short representative.

Right foot, Fig. 21. The cleft occupies the position of the 2nd metatarsal and the middle cuneiform, which are absent. The 1st toe is complete. The 3rd toe is not represented. The proximal half of the 4th metatarsal is present, and the 5th toe is complete.

Left foot, Fig. 20. The cleft occupies the same position. On its inner side is a complete 1st toe. On its outer side are the base of the 3rd metatarsal, the whole 4th metatarsal and the complete 5th toe.

(V, 46.) Miscarriage. The mother does not know if it was malformed.

(V, 47.) K. G. (approx. 1901, living). Left handed. All extremities screened.

Right hand. The 1st metacarpal has its base only, the others are normal. The 2nd and 3rd metacarpals bear each the base of a 1st phalanx. The 4th and 5th have complete phalanges which are syndactylised throughout by skin.

Left hand. The thumb is complete and has an extra phalanx. The 2nd finger has the metacarpal, 1st and part of the 2nd phalanx. The 3rd, 4th and 5th fingers have the normal complement of bones, those of the 4th and 5th being joined by skin.

Right foot. Toes 1 and 5 are present, their bones which are complete are much thickened. Between the cleft and the outer toe is a mass of bone representing probably the base of the 4th metatarsal. The tarsus appears to be unaffected.

Left foot. As usual there are two toes with a deep cleft between them. These are mainly composed of the thickened bones of the 1st and 5th digits. Between the cleft and the outer digit are the remaining three imperfectly developed metatarsals.

(V, 48.) W. G. (approx. 1903, living). Right handed. All extremities screened.

Right hand. The base of the 1st metacarpal is represented by a nodule only. The outer four metacarpals are normal. The 4th and 5th metacarpals bear complete sets of phalanges, syndactylised by skin.

Left hand. The hand is similar to the last, no part of the 1st metacarpal is seen however, and the 2nd metacarpal bears a short 1st phalanx.

Right foot. The foot is cleft at the 3rd metatarsal which is absent. The 1st and 5th toes are complete, and there are two masses of bone lying between these, one on each side of the cleft and representing apparently the remains of the 2nd and 4th metatarsals.

Left foot. This is practically identical with the right.

Generation VI. (VI, 1.) M. A. S. (approx. 1890, died a few weeks after birth). According to the mother, the right hand had an extra thumb, and the left had some slight abnormality of which no trustworthy account is given. The feet are said to have had two toes each with deep clefts between.

In the above description the normal individuals have not been included. A number of them have been seen and the reports of the family in respect of them have been confirmed. For th families of T. G. (III, 5), J. F. W. G. (IV, 6), and T. C. G. (IV, 14) we have had to rely on the statements of the remaining members, and have cross-examined several separately and so confirmed the statements with regard to them. The family of J. F. W. G. is no longer in England, and the present whereabouts of the other two families is not ascertainable.

Types of Split Hand and Foot, their Terminology and the Nature of Cross-bones.

With those cases of split hand or foot which are split by reason of their duplicity we are not concerned. Such cases have eight or ten digits on the affected extremity and are rare (see Murray and Giraldes). Our main purpose is the differentiation of the scattered forms of ectrodactyly, which yield a cleft hand or foot, from the hereditary and symmetrical type.

The majority of these irregular types (examples of which are referred to in Section C of the Bibliography), have been reported as single cases, some without reference to heredity, others with a definite history of normal parents. Kümmel has reported a family in which five individuals were deformed, by a splitting of one or both hands. At the same time he analyses a number of cases of split-hand and split-foot but without separating the types. In the cases which have been enquired into, the split usually occurs at the 3rd finger, and depends on the absence of the corresponding bones. It may be more extensive and include the 2nd and 4th fingers. Only one case of single split-foot, unassociated with other lesion, and in any way comparable to those of the "G" family, has been found. It is that quoted by Kümmel after Gintrovicz, in which the phalanges of the 3rd toe were absent. Further cases are figured in the older works in which anomalous forms of split-foot are associated with phocomelia and other extensive deformities.

When these irregular types are eliminated there remains a by no means uncommon deformity of which the "G" family presents notable examples. There are over 180 cases* of it now on record, in all but 13 of which there is a family history of similar defects. It is characterised by symmetrical clefting of the feet, with complete syndactyly of the remaining two groups of toes, and an irregular though often symmetrical deformity of the hands. Its marked tendency to become hereditary will be subsequently discussed.

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* In the following pages our account depends on an examination of about 100 cases of the deformity, in reports or in life.

Dealing first with those cases which have been reported as individual members of deformed families (see Bibliography, Section A), and including our own with them, the following conclusions may be drawn. All four extremities show deformity in the vast majority of cases. In a few one hand and both feet are affected[9] (V, 38)*, in a slightly greater number of instances the feet are alone abnormal[9, 11] (III, 7). The hands are never defective in the absence of foot deformity†. One foot is never malformed alone. The feet tend to illustrate one of three main types of malformation. Of these the commonest is that in which all metatarsals except the 1st and 5th are absent (Figs. 8, 9), or rather the 1st and 5th metatarsals are alone definitely represented. In the second type the main deformity falls on the 2nd toe (Figs. 20, 21, 24, 25), in the third type on the 3rd toe (Figs. 15, 16). The last two types are of about equally common occurrence‡. Although these main types may be isolated intermediate conditions remain. For descriptive purposes it may be said that, starting with the 2nd or 3rd toe as a basis, the lesion is extended§ to the adjacent toes in the order of their proximity. First the phalanges and then their metatarsals disappear. When one toe is completely absent in all its parts, which is the rule, the neighbouring phalanges are rarely if ever unaffected. Lastly this exception must be added, that the 1st toe tends in the vast majority of cases to escape. In a few instances this toe also is shortened||, and in some has been absent[3, 16, 17] (V, 24 and 31). In Perthes' case there was, in addition, affection of the corresponding cuneiform, navicular bone and astragalus, with some loss from the lower end of the tibia, but his case stands alone in this respect. Absence of the 5th toe must be equally rare. It may be shortened by the loss of one or more phalanges. Also it has happened that one or more phalanges have appeared to be absent when the 4th toe seemed to have its full complement (IV, 23), but it is doubtful if in these cases the phalanges have not been displaced. It is an almost rigid rule that a toe has fewer bony representatives according as it approaches the centre of the cleft. When the two outer toes remain intact they may be syndactylised by bone, but in any case they are joined by skin. There are frequently remains

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* The small number refers to the bibliography, the bracketed figures to the individuals in Plate I, Fig. 1.

† This statement is made somewhat reservedly. There is no reported case in which the hands are described and the feet are stated to be normal. If it does occur it must be quite exceptional.

‡ In comparing the frequency of types, the tendency in some families for one type to predominate, and the number of deformed members in each family have been taken into account. The examples referred to (Figs. 15 and 16) are not so decisive as many which occur in other families.

§ In speaking of the extension of the deformity it must be clearly understood that the word is used purely for descriptive purposes and is in no way intended to imply that such extension has actually taken place.

|| On the other hand it may be lengthened in exceptional cases by reason of the presence of three phalanges.

of tarsal bones and metatarsals in the cleft, but their welding together and disorder often preclude an accurate description, compatible with brevity (Figs. 15, 16, 21). It is an invariable rule that a proximal bone is never absent when a corresponding distal one is present. Of the metatarsals, which remain, those bearing terminal phalanges are usually considerably thickened while those which bear no phalanges show hypoplasia, which is greater peripherally. There are often indications that the thickening of the 1st and 5th metatarsals is due to welding with the remaining portions of the neighbouring metatarsals, namely the 2nd and 4th (cp. Figs. 8, 9, 15, 16).

From the detailed description of the "G" family and this general description it will be seen that there is a good deal of variation in the feet, but at the same time the points of resemblance are still more striking. In short these resemblances are the clefting with the absence of at least all the phalanges and half the metatarsal of one toe and the absence of one or more phalanges from neighbouring toes (Fig. 25), the syndactyly of all the remaining toes, or parts of them, into two groups, the broadening of the feet and the inturning of the terminal phalanges, and lastly the presence of split foot on both sides. *Briefly the variation in the deformity is of degree and not of kind.*

Passing to the hands, it will be remembered that they are not affected unless the feet are split. Also that in rare cases, one hand may be normal[9], or more often both normal[9, 11]. Further they may show syndactyly or polydactyly without other defect of the bones (IV, 3, etc.). There may be loss of one or more phalanges from one finger. Finally gross deformity may be found, and this is the rule. This again shows great variations but two general types may be separated. *In one* the hand is split, by reason of ectrodactyly of the 3rd (middle) finger. Such splitting commonly extends to, but not into the carpus*; on the other hand it may fail to involve the metacarpal (V, 7), and in this case the corresponding phalanges may constitute cross-bones. In a single instance[9] there has been a strong suggestion of division of the 3rd phalanges, the component parts lying to either side of the gap. As in the feet the process may be more extensive and involve the 2nd (Fig. 22) and 4th digits. *In the other* variety the ectrodactyly proceeds† from the radial side and the bones escape according as they approximate to the ulnar side. In this form it is usual for the 5th (Figs. 6, 7), or 4th and 5th (Figs. 14, 18, 19) fingers to have a complete complement of bones. Exceptionally no finger is complete. In two instances the 5th finger has shown more change than the 4th[17, 21]. The 3rd metacarpal is rarely and the 2nd usually affected; frequently they both carry one or more phalanges, those of the outer being more complete. The thumb is in most instances absent or represented by a short bone only, but it may show any grade from this up to the possession of all its bones (Fig. 23).

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* Affection of the carpus has been thought probable by writers [28 etc.] in certain cases, but no clear evidence of it has as yet been forthcoming. Through the kindness of Professor Pearson we have recently seen a case, as yet unpublished, in which it appears to occur.

† Compare footnote on page 37.

There are thus connecting links between the two main types (cp. hand of V, 7). The type in which there is preaxial affection as opposed to splitting is a little commoner. In neither type is the radius or ulna ever affected, and it can only be in exceptional cases, if in any, that the carpus suffers. Both types may be associated with syndactyly or polydactyly.

Syndactyly is generally confined to the 4th and 5th digits (Fig. 14), but when more are present and complete it may unite these; the rule is for two adjacent fingers to be united by skin when they have phalanges. The union may be by the deeper structures as well, and in a fair number of cases is bony*[11, etc.] The subject will be reverted to under the discussion of the cross-bones.

Polydactyly occurs less frequently. The supernumerary digits may be rudimentary[5], the extra digit may be articulated to the end of a phalanx (V, 38), to the end of a metacarpal (V, 6, 7), or to the carpus[30]. It may be fixed to the side of the thumb metacarpal (V, 6). When articulating with the end of a metacarpal or carpus the digit is fully developed and has three phalanges, even when the joint is between it and the 1st metacarpal. Thus the varieties of polydactyly which occur are similar to those found when unassociated with other lesions (cp. Annandale). It occurs most commonly in those split foot cases where there is no other affection of the hands but is not confined to these (V, 6). There is only in isolated cases more than one extra digit on each hand†.

Thus it is seen that the hands show even more variation than the feet; nevertheless they show points common to the majority. Notably the mobility, the fleshy pads over the abnormal bony prominences, contractures and syndactyly of remaining fingers, and the exemption of the carpus. When the two main types are taken separately the bony deformities in different individuals show very close resemblances, as detailed above; moreover there are connecting links between these main types.

It has now been shown how much both hands and feet vary, but that in spite of this *there are points of strong resemblance between the affected limbs of different individuals.* Moreover there is a variation, usually limited, on the two sides of the body and the variations of hand or foot appearing in different families are strikingly similar. Thus in the larger families["G," 5, 9, 11]‡, though there may be a predominant type, *yet it is the rule for each family to provide examples of many types, and in one family almost all types are represented*[11]. Again it has not been found possible to connect the occurrence of any particular type of foot with any particular type of hand. It was at first thought that the type of foot in which the split occurs at the 2nd digit might be more often found in association with that type of hand in which the preaxial side is mainly defective, and that splitting of the feet and hands at the central digit might be found to occur more commonly in conjunction with each other. But when allowance is made for the tendency shown here and there for the transmission of a particular type these relations do not hold. *With few exceptions each type of foot is found in association with each type of hand.* Lastly, although in certain families, as in that of Mayer, such a combination as split hand and split foot occur together and predominate, yet there are *families in which many combinations of types are blended.* Dealing with the main facts, it may be said that when this quadruple deformity, which presents extreme variation of form, exists as a hereditary malformation, the constantly occurring similarity between individual parts and individual combinations, when taken into account with the common tendency to transmit along definite lines, leads to one conclusion, *namely that in all these families the deformity of each individual has the same fundamental basis; in fact that the deformity is a distinct entity.*

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* In these the union is closest at the distal end, and the nails are united in a central furrow.

† For exceptions see [5, 18].

‡ "G" signifies the family now reported.

It now remains to bring into line those cases which have been reported as isolated cases (Bibliography, Section B). At first sight the absence of the hereditary history sharply breaks them off from the familial cases so far discussed. There are in all, however, only 13 cases of which we can find descriptions or figures, and of these eight are not dealt with from the hereditary standpoint at all. In five it may be assumed that the parents were normal[23, 25, 26, 28, 31], but two of these were children and the third a lad. In some of the 13 cases there is consequently a possibility that the question of heredity was neglected, in others there was no opportunity of studying it. In yet other cases the absence of hereditary history may have been due to the reticence of the patient; from our experience of the "G" family we may say that had we first met certain members of the family now known to us, we should have had great difficulty in extracting the necessary information. Illegitimacy, several examples of which we have ourselves met, provides another possible source of error. Again a certain proportion of the 13 cases are likely to have been the first in their family to show deformity*. Lastly it is more than possible that a deformed person may have the potentiality of transmitting and still fail to do so. These considerations lead us to believe that some if not all of the isolated cases either actually belonged to deformed families or were by no means lacking in the power to transmit the malformation, and there is consequently no reason to exclude them upon this score. Moreover, considering their deformities, *no isolated case occurs in the list which is given which does not find its almost exact counterpart in members of the families given in section A.* Consequently as there is little hesitation in regarding the familial cases as examples of the same entity so it is considered that the isolated cases, though varying widely, are of the same nature and may be classified with them as illustrating a deformity *sui generis.*

Having now, as we believe, established† the deformity under discussion as an entity, the terminology may be briefly referred to. So many terms are found in the present nomenclature that confusion is unavoidable. "Perodactyly," "Peromanus," "Peropod," "Perochirus," "Ectrodactyly"; "club-foot," "split-foot," "crab or lobster claw," and the foreign equivalents "Hummer-Schere," and "main ou pied en pince de homard" are a few of its more simple designations. Many of these terms are applied to a variety of malformations and none are sufficiently comprehensive as descriptive terms. We are not concerned with any other class of split-hand or split-foot but that of which the "G" family presents examples, and in consideration of the constant and fundamental character of the foot lesion*, the term "Hereditary Split-foot" is proposed for this deformity†. The term is perhaps insufficient in that it contains no reference to the defect of the hand, but the variability of the latter is so great that no adequate term is possible without lengthening it to an undesirable extent; moreover there are cases in which there is no defect of the upper extremities.

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* The proportion of original deformed members to those occurring in the 19 families is approximately as 1 is to 8.

† It is not possible to bring forward the complete evidence in support of this view, as space does not permit, but those who are acquainted with the reports and figures cannot fail to be struck by the close similarity of separate cases. The position is in reality far stronger than it can be made in a general outline sketch.

The nature of the cross-bones. This is a subject of very considerable interest, and particularly in the "G" family. What may be termed the clean form is illustrated in Figs. 6, 7. These straight bars of bone‡ have shafts with concave borders and end in articular surfaces, each of which may in young subjects be shown to have developed from a special epiphyseal ossification centre. In older subjects there are indications of the same. A cross-bone has not been met with in a sufficiently young hand to enable us to identify the centres of the shaft, but in some there is an indication of its double origin (Fig. 12). The outer articulation is a triple one in which the base of the 1st phalanx and the head of the metacarpal bone take part. The cross-bone may bridge over the space between the heads of the 4th and 5th (Fig. 6), or the 3rd and 4th (Figs. 14, 19) metacarpals. The outer extremity of the cross-bone has two facets, the inner extremity one facet, which may or may not be in contact with the head of the metacarpal corresponding; in the latter case the articulation is with the side of the head or shaft of the cross-bone. The type illustrated in Figs. 6 and 7 occurs in the hand of IV, 17 (Fig. 11) and in both the hands of V, 39 and 41, the children of IV, 23. Articulating with the 3rd and 4th metacarpals it occurs in both hands of another member of the same family, namely V, 45 (Fig. 14), and in one hand of V, 42 (Fig. 19), and V, 24. These two types have been found in no other members of the "G" family. The irregular forms occur in IV, 17's right hand (Fig. 10) and in both hands of V, 40 (Figs. 12, 13). Thus cross-bones are limited in this family, so far as we are able to judge, to IV, 17, her eldest child, and her brother's children, but from the description of their father's hands (III, 2) it appears probable that he was similarly deformed, and also other children of IV, 17 herself. Of the five deformed children of IV, 23, four have cross-bones in each and the fifth in one hand, and this in spite of the fact that the father's hands are free from it (Figs. 22, 23).

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* The constancy of the foot deformity as opposed to that of the hands may possibly be associated with the phylogenetic evolution of the extremities. The feet being considered as undergoing retrogressive and the hands progressive development.

† The term has the additional advantage of being in unison with the German appellation "Spalt-Fuss."

‡ Which are now recorded for the first time.

Cross-bones of a somewhat different character have been reported by many writers[8, 9, 11, 12, 13, 46 etc.], and have been discussed by Perthes. Such cross-bones are obviously displaced phalanges, lying across the head of the 3rd metacarpal or articulating with phalanges of the second row. The method in which such cross-bones, as are figured in v. Bergmann's *Surgery* (Figs. 183, 184), are formed is strictly comparable to the method of production of a distal bony syndactyly. The hand shown in Fig. 10 shows a very similar condition, though more advanced. In this figure though the 1st phalanges appear to be united, yet when screened there was a doubt about it. The main cross-bone in this figure can only be interpreted as the 1st phalanx of the 4th finger, and the shorter piece, perhaps united with it, as the corresponding phalanx of the 5th. A similar explanation will not apply to the type shown in Figs. 6 and 7, for complete sets of phalanges spring from the triple joints. Moreover the presence of two epiphyses precludes the possibility of interpreting the cross-bone as one phalanx. A further explanation must consequently be sought. Now there can be but two possibilities, for either the cross-bone is an entirely new formation or it is developed from the representatives of parts normally present. In regard to the last there are two explanations, the cross-bone may represent phalanges or metacarpals. The latter is excluded by such hands as the left of V, 45, in which all the metacarpals are present. The cross-bone may thus be said to represent either united phalanges or to be an entirely new formation. If the former view is adopted the phalanges concerned must necessarily be those normally situated further to the radial side of the hand than the position of the cross-bone itself; for instance in the right hand of V, 45 (Fig. 14) they should come from the 2nd and 3rd digits, and in V, 41 (Fig. 6) from the 3rd and 4th. There is no difficulty in the way of accepting this displacement, for such cross-bones are the only possible representatives of the phalanges corresponding to those fingers which lie between the space bridged by the cross-bone and the thumb (compare the hand of V, 40 (Fig. 13) and the subsequent explanation of her deformity). The view that the cross-bone is developed from ossifying centres which normally represent phalanges is by far the most plausible and is further supported by the following considerations. In all the cross-bones there is a strong resemblance between the extremities of the bones and the bases of 1st phalanges. In the right hand of V, 40 (Fig. 12), the cross-bone is bent and indicates such a union. In the hands of V, 42 (Figs. 18, 19) a cross-bone on the left side (Fig. 19) is replaced on the right (Fig. 18) by the proximal half of a 1st phalanx. Lastly there can be no doubt that in the cross-bones shown in Figs. 10 and 13 phalanges are represented, and when this is taken into consideration with the fact that cross-bones in other families can only receive rational explanation in this way further evidence is hardly wanting. Our conclusion is that in the hands of V, 41 (Figs. 6, 7) the cross-bone represents the united bases of the 1st phalanges of the 3rd and 4th fingers, welded together and displaced inwards*.

We now come to the hand of V, 40 (Fig. 13). In this the presence of the base of the 1st phalanx of the 3rd finger precludes the possibility of displacement†; as a matter of fact such a supposition is unnecessary, for the cross-bone may be said to represent the 1st phalanges of the 4th and 5th fingers. The first being horizontally and the latter vertically placed and much thickened. The U-shaped bone is the representative of the 2nd row of phalanges. It is noteworthy that the terminal phalanx of the 4th finger shows an indication of being double, but however the deformity is explained the same difficulty will arise. The deformity of the hand is so gross that so small a factor is of little consequence.

In concluding this section it is worthy of note that although the cross-bone formation is so closely allied to the process of bony syndactyly, and that this occurs in hands and feet, yet cross-bones are never observed in the lower extremities.

Origin and Transmission of the Deformity.

(*a*) *General.* In entering upon a discussion of the origin and hereditary transmission of a human deformity, there are several considerations of importance. But before discussing them it is desirable to lay particular stress upon one fact, namely that the origin of the deformity in the first member of the family affected may be—but is not necessarily—a question entirely apart from that of its transmitted origin in later members of that family. Confusion of the two problems arises so frequently in medical communications that this emphasis is imperative.

Comparing the standpoint of the clinician or pathologist with that of the vegetable teratologist, it will be seen that the former labours under distinct disadvantages. For the latter is aided by the prolific nature of the material with which he works, a vast number of progeny arising from a single parent and one generation following rapidly on another. Moreover the material is under control; not only is he able to restrict the complicating factors by inbreeding, but from the hermaphroditic nature of much of the material he has the opportunity of tracing hereditary characters in a stock derived from a single ancestor. Those who investigate the smaller, more fertile and quickly breeding species of the animal kingdom, enjoy similar but more restricted advantages. The human teratologist on the other hand must work entirely with the mixed material provided by the irregular intermingling of a community. Rarely has the investigator of a human family the opportunity of examining three generations, and often but two or one; his information has therefore to be drawn to a large extent from hearsay evidence, or from the old and oft-times misleading accounts of other members of the family.

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* Corresponding explanations apply to the other bones of this type. A rational elucidation of the hand shown in Fig. 17 has not been obtained.

† There is no reason to believe that an actual displacement ever takes place, but that the bone is developed *in situ* is certain from the nature of the articulations.

It is of first importance, from the point of view which we are considering, that in reports of family affections the whole genealogical tree be investigated as accurately as circumstances permit. Many of those who have written on deformities of the hands and feet have contented themselves with an account of affected members only. The tendency of members of the later generations to be acquainted only with the deformed relatives preceding them is very great and the fallacies arising from it must be carefully guarded against*. It is possible that certain cases in which dominance of deformed members is in great excess in the earlier generations may be accounted for to some extent in this way.

Although clinical observation may fail to contribute so richly to the questions at issue in dealing with hereditary problems, as do observations on the lower grades of animal and plant life, and though to a large extent laws formulated from the latter must serve as a basis in the discussion of similar problems in man, yet the study of hereditary deformities forms a by no means unproductive field of research. And the harvest from it remains at present almost totally ungathered.

The principles governing transmission in man are assuming daily an aspect of greater importance, both from the academic and practical standpoint, and there is every prospect that their elucidation will be of vital importance in the near future.

(*b*) *Maternal impressions.* In the literature of deformities of the extremities a history of maternal fright occurs with great constancy. It appears to be as great a matter of indifference, as to in what period of gestation the "impression" was produced, as it is of little consequence whether the child's deformity is identical with the object which is attributed as its cause.

In connection with our family, Anderson originally stated that the condition was attributed to a packet of lobsters. The legend is now content to impute it to a crab. The whole subject would be unworthy of mention were it not for the fact that the superstition is not only firmly rooted in the minds of the lower classes, but appears to find favour with certain medical writers[5, 61]†. It is to be explained in great measure by their want of recognition of common teratological defects and monstrosities. We have no intention of dealing further with a theory which has been satisfactorily interred by numerous writers, but content ourselves by referring to the remarks of Förster, Vrolik and Lewis.

(*c*) *Origin in an acquired lesion* (*Extrauterine*). The old controversy of the Lamarkian doctrine, as opposed to the antagonistic theory of the exclusive transmission of "in-born" characteristics, is one which it would be out of place for us to enter upon at any length.

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* To those who have never undertaken the task of compiling a genealogical tree of a family of working class people the difficulties may not be apparent. Taking the "G" family, it is the rule for the adults to be unaware of the names of many of their brothers and sisters and it sometimes happens that the names and number of the children are unknown to a parent.

† The possibility is discussed at some length by some writers, who have mentioned the possibility of transmission by recurring "impressions" from the children (compare [11]).

Both the family of Kümmel* and that of Scoutetten arose from a parent with an acquired defect of the limbs, and the last author actually attributes the defect to this source. He has been criticised for so doing by Perthes. It is almost needless to say that there was no evidence that the deformity of the offspring was in any way comparable to that of the parent. With this solitary example, which has been successfully controverted, there is no particle of evidence in a single case to show that such transmission has taken place. The supposition can be dismissed.

(*d*) *Arrests of development.* There would be no occasion to refer to this subject were it not that syndactyly is very constantly associated with the split-foot deformity, both in single and familial cases. Further syndactyly has been frequently attributed to this cause. Cleft or deficient palate has also been met with in two split-foot cases. The question can however be dismissed in a few lines. Were the theory of the production of syndactyly in this way tenable, it would raise the needless question of a duplex origin for the combined deformity in the majority of cases, for split-foot can certainly not be accounted for in like fashion. But there is evidence that so arise few, if any, cases of "webbed" fingers. This has been shown by Sutton, Windle and others, and the arguments against it apply with particular force to the cases where the syndactyly is incomplete or bony.

(*e*) *Atavism.* This is often mentioned in connection with split-foot deformities, but in such an indefinite fashion that it is impossible to understand clearly the extent and nature of the reversion to which writers allude. There is a suspicion that they have had in their minds forms phylogenetically remote†. And in a few instances[5] the Quadrumana have been tentatively referred to. A deliberate statement on the subject no one has been bold enough to make, and not the slightest trace of evidence has been put forward in favour of the suggestion. It is of chief interest in that polydactyly has received a similar explanation. The two deformities are intimately associated, and as has been stated in the last paragraph a duplex explanation of origin is objectionable. The view that polydactyly may be atavistic seems to be based largely on the observations and deductions of Bardeleben, who investigated the comparative anatomy of the digits. He is answered by Sutton, Windle and others, who attribute polydactyly to a "sport"; and also by Wiedersheim, who concludes that from the palaeontological point of view the condition of "hyperdactyly" loses its supposed atavistic significance.

The ultimate origin of split-foot conditions and their associated defects in man by a "throw back" can therefore be denied, but there still remains the possibility of its transmission by this means. It might be argued that the original deformed members have arisen from a common ancestor, and that the malformation has lain buried in the intermediate unaffected members of the family. Now an affected individual is never to be found arising from a normal parent, himself the offspring of a deformed individual. Yet in one case a member of a deformed family is said to have had syndactyly only (Mayer), and in another (Anders) the grandfather was reported as having syndactyly of the hands. But from the accounts it would seem that one at least of these cases was not examined, and that consequently foot affection cannot be excluded, and in the other similarly there is no mention of feet*. Thus while a possibility remains it can nevertheless be stated as improbable in the highest degree; the records contain cases in the Mongolian races[12, 13, 18]; also the absolute identity of the defect in different cases is absent. There is no example of intermarriage of two undeformed members of deformed families, an instance of which might throw light on the matter.

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* Kümmel's case is one of split-hand only. It is discussed by this author from this point of view. His views on the origin of such deformities will be subsequently mentioned.

† "Atavistic parts do not belong to forms palaeontologically remote or systematically far distant" (Sutton, p. 135).

Lastly atavism might be brought forward in explanation of the fact that a variety of split-foot deformity may skip one generation to reappear in the next. It remains to be shown however that the deformity in grandfather and child is identical as well as similar.

(*f*) *Origin as a result of Intrauterine conditions.* The question of the origin of split-hand or split-foot by reason of intrauterine lesions is of frequent occurrence in the literature, and the German authors have devoted special attention to it. This explanation has been accepted by Kümmel for all such malformations, and for some of them by others[13, 22]. It has been supposed that the deformities may be produced in the following ways.

1. By an injury to the abdomen from without.

2. By an amputation of digits through strangulation.

3. By the pulling away of the central digit during the contraction of adhesions or the growth of the child.

4. By the splitting of hands or feet through the pressure of bands or folds of amnion, or by the umbilical cord.

The majority of writers have been dealing with single cases, and so far as single split-hand and atypical single split-foot are concerned it cannot be denied that this explanation will in many cases suffice. Kümmel has been criticised by Perthes for extending his hypothesis to hereditary cases, but the arguments of the last author lose their strength if there is any possibility of the transmission of characters acquired *in utero.* We are unaware of a case of single split-foot which can be brought within the category of the cases we are discussing, and great difficulties in accepting the hypothesis are met when the symmetrical and hereditary cases are dealt with.

Intrauterine conditions might be involved in the production of deformities in

(1) the original deformed individuals, whose deformities are transmitted;

(2) the original individuals whose deformities are not transmitted;

and (3) in those individuals to whom the deformity has been transmitted.

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* The only reference to the grandfather in Anders' paper is as follows:—"Der Grossvater des Kindes litt an Syndactylie einer Hand."

Lastly they might be involved at a very early or at a later period of development.

The views, which have been held, deal, as may be seen from what has already been said, with the origin at a later date. So far as they apply to the origin of the malformation in those members of a family who have inherited the defect*, they may be at once excluded, for the lesions are in the four extremities in the majority of cases; they are fairly symmetrical; they are similar in different individuals; there is no evidence of similar and simultaneous affection of any other part† of the body; and one of two twins may be alone affected[4, 9, 11]. Again actual evidence of bands, adhesions, or amputated digits has so far been in no case forthcoming‡. The argument that there should be transmission through the female only is insufficient, for the amnion certainly and perhaps the amniotic fluid too is of foetal origin. Lastly the theory involves the supposition that acquired characters are transmitted.

Possibilities 1 and 2 may be considered together, for arguments have been already produced to show that all such individuals are examples of an entity, and that all such deformities would be transmitted if the opportunity arose§. Now if these original members are examined it is found that they differ in no way from the later members of families. As a whole they show the same general characters and the same variations. And this similarity suggests that a similar fundamental factor is at fault in the production of the original and subsequent deformities. But as has been previously stated the mode of origin is not necessarily identical, and it can only be stated that in all probability there is much in common in their production. Further arguments have consequently to be considered. The evidence which refutes the possibility of the origin of deformities in the later members of a family in intrauterine lesions applies to a great extent to the original members, particularly the symmetry, the quadruple nature of the deformity, the similarity of the separate individuals and the absence of evidence of such lesions. And these facts are stongly in favour of the existence of the cause, whatever it may be, at a time when a common factor may act simultaneously upon four masses of formative material, representing the four extremities respectively, or of its existence at a time when all four extremities have a common representative. But in any case the evidence necessitates the assumption that the cause exists at a very early period of development, and certainly prior to the division of the ovum. The great functional capacity of the deformed limbs is in itself a proof of the early laying down of the hands and feet in their malformed state.

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* It is to these that the arguments of Perthes particularly apply.

† It must be noted that in two single cases the deformity has been associated with deficiency of the palate.

‡ In the case of J. A. (V, 38) which we have described anything of the kind certainly did not exist.

§ Weismann criticising Zander's opinion that polydactyly arises as a result of the action of amniotic threads on the finger-buds says that such a view is untenable in cases where there is a hereditary history.

Abnormal intrauterine conditions can consequently be rationally assigned as the cause of the deformity only if it be supposed that they are present at this early period; and if it be granted that the origin of the original deformed and later members takes place by the intervention of similar agencies, a position which is strengthened by considerations already alluded to, it becomes practically certain that the process must be regarded as occurring at a still earlier epoch. For a deformed man may have as in Mayer's family deformed children by separate and normal wives, and therefore the deformity must exist in a potential form in the germs of the father.

In the next section this line of reasoning will be further pursued.

(*g*) *Origin as a sport.* The main alternatives have now been considered and, by a process of exclusion and from the outcome of the discussion upon the relation of intrauterine conditions to deformities, it may be concluded that the factors concerned in the causation of hereditary split-foot exist very early. The deformity is in fact a sport, and its association with polydactyly and syndactyly confirms this conclusion.

Weismann was of opinion that polydactyly is due originally to a germ variation, and considered that it must be so when the deformity is transmitted. Windle states that two main views have been held in the case of duplicity, either that the deformity has arisen from the inclusion of additional germ plasm, or that a fission of formative material has taken place. It might similarly be concluded that conditions of deficiency are due to deficiency of germ plasm, or to a failure of fission of the formative material. So far as ectrodactyly pure and simple is concerned, these explanations might suffice, but in the case of the variety of split-foot which we are discussing they are insufficient. For the deformity may be associated with polydactyly, and with bony syndactyly of such a character that it alters the whole conformation of the hand. Further they fail to offer a rational explanation of the differences found in individual sports, which are in all probability collectively an entity. It is in the general conformation rather than in the development or non-development of individual bones that the fundamental defect lies. The normal regularity of conformation and the morphological resemblance of hands and feet can only be explained by assuming that, in addition to the presence in the germ cells of determining factors for the constituent parts of the extremities, there must exist factors determining the arrangement and growth of these, either separately or collectively (cp. Weismann). There is consequently in the case of certain deformities a necessity for assuming a defect in those factors which govern the conformation of the extremities, when the allocation of the origin of the deformity to a particular stage of development is desired. Theoretically the defect may arise at any period in the life history of either germ cell or in the fertilised ovum prior to its division, or by a combination of certain factors in both germs at the time of union. But the latter supposition necessitates the superfluous assumption of variation in the germ cells of both parents. Also both this and the assumption that the variation may occur in the ovum itself, which can only be allowed if it can be shown that characters acquired *in utero* may be transmitted, are discountenanced by the statement of Vrolik that a normal father may give rise to two similar sport offspring from two separate normal mothers. There is however no recorded example of this sort as far as split-foot is concerned, and the argument therefore rests upon analogy; but it may be said that on the whole the evidence is in favour of the presence of potential deformity, such as split-foot, *in those factors in the germ cell which eventually influence the conformation of the hands and feet.*

When the enormous waste of sexual cells from both male and female genitors in the process of procreation is considered it becomes extremely probable that a vast number of sperms and a large number of ova contain the necessary generating factors of the deformity; for otherwise the unlikelihood of a malformation ever showing in the next generation would be overwhelmingly great. The hypothesis is much strengthened by the fact that more than one deformed child may arise from the same normal parents[8, 13]. It must also be remembered that at least 30 such sports have been reported as occurring. If the position is accepted it follows that when all sports are considered a large proportion of the human race have the potentiality for producing such defects in their offspring. Also it follows that, if a similar potential deformity exists in an abundance of cells developed from a single individual, we have to choose between the possibilities of the origin of the determining factor in a single common precursor of these cells, and the origin of similar defects in each germ cell separately. The former is obviously the more plausible[*]. It remains for us to further discuss the nature of the particular sport with which we are dealing, and in so doing shall prepare the way for the consideration of certain suggestions relating to sport characters, which have recently been prominent. It has already been pointed out that there are records of over 30 instances of the origin of this same sport[†], and that whenever it occurs it tends to vary, when opportunity is given it, in the different individuals of the families. An apparent example of a sport tending to multiple variations, and one which we are inclined to regard as parallel to hereditary split-foot, is the remarkable plant *Oenothera Lamarkiana* and its mutations, discovered by de Vries. In all cases where families of split-foot have been described the variations have occurred, but what is no less remarkable is that the same sport, arising on so many separate occasions, has shown variation along lines showing close resemblance. The facts are so striking as to suggest that nature's sports are not so erratic as they might at first sight seem, *but that they tend to occur in definite directions and along definite lines.*

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[*] In assigning the origin to precursors of the sperm cells or ova, the unusual and recently discovered types of nitosis in these cells are not forgotten. But at the same time we cannot commit ourselves to a theory of origin or transmission through the medium of any particular anatomical structure. It is for this reason that we have avoided the use of the word "determinant," as it is too closely associated with these theories.

[†] In regard to this statement it is essential to point out that in a small proportion of the cases, there has been no mention of descent from healthy parentage; the possibility of two or more of them belonging to the same family can consequently not be placed entirely out of court, though its improbability is great. Moreover it must be remembered that although in the families examined there is no instance in which the deformity skips a generation, yet the presence of deformity in collateral branches cannot be absolutely excluded. Our subsequent conclusions must therefore be read with due regard to these possibilities.

(*h*) *Transmission of hereditary split-foot, its stability, and the relation of its mode of transmission to Mendelism.* The arguments which assign the origin of hereditary split-foot to a sport have been fully considered and we are now in a position to discuss the mechanism of transmission from this point of view. In dealing with the types and combinations of types sufficient has been said to show the similarity of these in different families. In any particular family[*] it is impossible to predict the exact deformity or even the type of deformity which will occur in the offspring of an abnormal parent; all that can be prophesied is that the deformed children will conform to one or other of the general types. In a fair percentage of cases however direct transmission of a type from parent to offspring or indirect to a grandchild through a child of a different type is found. The nearest approach to uniformity of type is presented by Mayer's family in which split-hand occurs in almost all the individuals reported; in one instance through three generations. In the same family is an example of a father with both feet and the right hand affected transmitting the same defects to his son (Fig. 2, II, 2 III, 10), also an instance of transmission from father to son of deformity confined to the feet (Fig. 2, II, 3, and III, 11). Two examples of the last are also to be found in Parker and Robinson's tree. In Fotherby's report polydactyly occurs frequently and is transmitted once. In our own family polydactyly occurs in grandfather, mother and daughter (IV, 3; V, 6; VI, 1). Transmission missing one generation is illustrated in Parker and Robinson's family where three grandchildren "revert" to the type of the grandparent who was deformed in all extremities, while the mother of the children had perfect hands. The same occurs once in the "G" family (II, 2; III, 7; IV, 31). The limitation of a type to a branch of a family is fairly well seen in the occurrence of cross-bones in all the children of IV, 23. But although these instances occur with sufficient frequency to merit attention, yet there is no constancy of the inheritance of individual peculiarities.

As these examples are the only striking instances of particular transmission happening in the four fully reported families mentioned, it may be said that they are the exception rather than the rule. And from the instances cited it follows that though examples of direct transmission of types occur too frequently to allow of their explanation as coincidental, yet there is little evidence of their transmission in a stable form[†], and it must be admitted that while a lesser deformity (such as that of feet only), may occur, nevertheless the individual *showing* this lesser malformation may transmit the full defect to offspring. The actual deformity in an individual is thus no index of the potential deformity transmitted to that individual.

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[*] In the following, the larger families [“G,” 5, 9, and 11], are alone dealt with.

[†] It is true that examples of split-foot and polydactyly of the hands are reported in three successive generations, yet in no case are the deformities identical.

The partial suppression of deformity in one generation has been referred to in dealing with atavism, but the latter, even if applicable as a term, offers no reasonable explanation of the phenomenon. It might be supposed that this partial "latency" could be brought about by the intervention of other characteristics which might themselves be transmitted*. As it is only in exceptional cases that the deformity of a parent is a gauge, and even then a by no means strictly accurate one, of the malformation which will appear in the offspring; and as at the same time the deformities in both parent and offspring, as in all members of a family, may be said to have been cast in the same mould, there is strong presumptive evidence that the inheritance depends on the transmission of some common factor. That representatives of the deformity are not transmitted in detail is obvious, for no two individuals have as yet been reported in any family in which the deformities were identical. Also in view of these multiple variations, it appears inconceivable that the originating factor is a recurring variation in the representatives of the hand or foot in the germ cells. It seems far more probable that a fundamental factor, which influences the ultimate general conformation of the affected parts through their normal representatives, is at fault, that it is transmitted, and that its interaction with these representatives varies slightly in quality and quantity in different individuals and generations; and that the varying interaction is produced by the interference of factors which may or may not be transmitted, such as those which may be conceived to account for the partial latency above mentioned. Such an hypothesis would not only offer a rational explanation of partial latency, but would render the quadruplicity of this and many other deformities less inexplicable; at the same time accounting for the marked tendency to symmetry which usually exists. The hypothesis is in accord with the observations of Weismann on the subject of polydactylism (cp. Wilson and Windle also). Whatever view be taken it is difficult to avoid the conclusion that in spite of the variation in individual deformities, there is a common factor and fundamental scheme in transmission, both as far as hands and feet are concerned.

Before passing to the inheritance of the deformity as a whole there remain two considerations; the first in connection with sex preponderance, the second with twins.

In Bédart's short family there was a predominance of the female sex in the proportion of 2 to 1, though taking deformed and undeformed together the male element was in the ascendant. In Mayer's report there is a male excess in the proportion 6 to 1 (Fig. 2). Apart from these examples sex plays no part in transmission, and therefore requires little comment.

There have been in all four cases of twins. In two of these[4, 11], where the twins were heterologous, the female was in each unaffected. In a third instance (V, 33, 34), two children of opposite sex were normal. Lastly of Mayer's homologous twins (Fig. 2, III, 6, 7), arising from a deformed father, one only was deformed. Interest attaches itself to this case in view of the opinion that certain homologous twins result from the fission of a single ovum. We can only conclude that in the case of Mayer's twins such an origin is highly improbable.

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* A phenomenon related to if not identical with the "cryptomerism" of Mendelians.

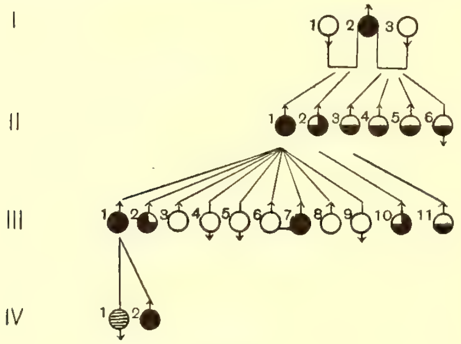

Fig. 2.

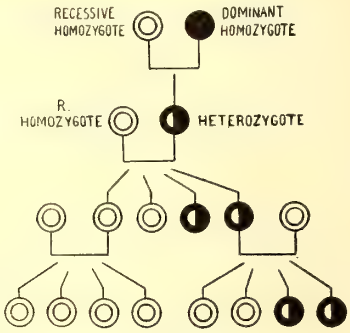

Fig. 3.

Fig. 2. The figure illustrates the deformities of a family of hereditary split-foot described by Mayer (loc. cit.). The arrangement and signs correspond to those of Fig. 1. The family is of special interest as it shows:—marked dominance of the deformity: offspring from two wives by the original deformed member: male predominance: inheritance of type (II, 2 and 3, III, 10 and 11): and homologous twins of which one is deformed (III, 6 and 7).

Fig. 3. Diagram illustrating Mendelism as applied to human sports. The horizontal and oblique lines are to be interpreted as in Figs. 1 and 2. Each individual is represented by a double circle, the outer representing the appearance of the individual (black deformed and white normal), the inner circle divided by a vertical line the nature of the gametes. Homozygotes are consequently represented uniformly in black or white; heterozygotes with the outer ring black (signifying the actual deformity and illustrating the dominance of the same) and the inner ring half black and half white, to denote the potential deformities of the gametic cells. In the figure a recessive and dominant homozygote are supposed to be crossed, producing heterozygotes only, one of which is shown. This individual is then crossed with a normal or recessive homozygote with the production of equal numbers of homozygotes and heterozygotes. Of these offspring one of each variety is crossed with a normal homozygote. The figure shows that from heterozygotes when crossed with normal individuals an equal number of deformed and normal offspring are to be expected.

We now come to a subject of considerable interest and importance, in the discussion of the transmission of the deformity as a whole. There appears to have been of late years a growing feeling that slow or continuous variation is insufficient to account for the origin of widely differing species (cp. Lock), and a tendency to attribute such species to discontinuous variation or sport. The essential consideration in view of the possibility of a new species originating in a sport, is the stability of the particular deformity in its transmission. Weismann stated that there is no difficulty in understanding the gradual swamping of sports, when it occurs, and even went so far as to assert that it is inevitable in the absence of inbreeding. But Weismann based his statements chiefly on theoretical considerations, and the "id" hypothesis in its application to sport characters is perhaps no longer free from doubt. In the recent revival of Mendelism a great many new observations have been made into the subject of "hybridism." The investigations have been made for the most part upon the vegetable and lower animal kingdom, and the term "hybrid" is now given wider scope. Bateson in a recent communication has suggested the applicability of Mendelian laws to hereditary pathological and teratological conditions. In the ensuing paragraphs the applicability of these laws to hereditary split-foot will be examined; for if the cross between a deformed individual and a normal one is to be designated as a hybrid, and if the transmission of any deformity can be shown to proceed along Mendelian lines, the question of permanent stability of that deformity upon transmission may be considered as settled in the affirmative, and the possibility of a human sport originating a species, in the wide sense of the term, will be past denial.

According to the Mendelian doctrine animals and plants cannot be considered, from the point of view of heredity, as "units," but as composites of separate characters. If as a result of the crossing of two individuals, bearing separate types of a single character, these types segregate independently in the offspring, they are termed "allelomorphs" and may be expected to obey certain fixed laws. A fundamental proposition of Mendelism states that it is impossible for the same gamete to carry more than one member of the same pair of allelomorphs. Again, one allelomorphic character may show dominance to the other member of the pair, in which case the result of the cross between a "dominant" and "recessive" allelomorph will be the appearance of offspring all bearing the dominant character*. The offspring will nevertheless produce an equal number of gametes carrying dominant and recessive characters. Such offspring are termed "heterozygotes," as opposed to those arising from the union of like allelomorphic gametes, which are termed "homozygotes." When a heterozygote is produced by the union of a dominant and a recessive allelomorph, and is crossed with a homozygote resulting from the union of two recessive allelomorphs, homozygous offspring bearing the recessive character and heterozygotes bearing the dominant character will be produced in equal numbers. This principle is illustrated in the accompanying diagram (Fig. 3).

From this necessarily short account† it may be gathered that when dealing with allelomorphic characters an abnormal offspring cannot arise from recessive homozygotes, and that in a family tree arising from an abnormal ancestor the deformity may be expected to be stable. It also follows that the abnormal offspring of one normal and one abnormal parent is a heterozygote.

We have seen that there is reason to believe that a sport in all probability arises as the result of the union of a normal and an abnormal gamete. It may be therefore assumed, if Mendelism is to apply, that the original sport is a heterozygote, an assumption which Bateson appears to have made. From this it follows that if a family is in agreement with Mendelian laws the total number of deformed and undeformed offspring from deformed parents should be equal.

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* If the sport character is recessive, it can never appear in the family unless there is intermarriage.

† Which for simplicity takes no account of "latency."

The counts for split-foot families are as follows:—

Parker and Robinson's...16 deformed and 16 normal.
Ours ....44 deformed and 32 normal.
Fotherby's..................16 deformed and 10 + normal.
Mayer's......................12 deformed and 6 normal.

Thus there is a greater dominance* of the deformed than is to be expected, though several of the families are fairly in agreement with the rule. But we have now to proceed a little further.

It has been stated that the original sport should be a heterozygote, but in the family of Mayer (Fig. 2), all the members of the second generation show the dominant character, namely are deformed. On Mendelian principles this would be brought about if the original sport were a homozygote. But if this is assumed there is every reason to assume that every original sport of the sort is a dominant homozygote also, and this cannot be allowed, as were it so all children of the second generations should be invariably deformed, which they are not. Moreover it is the rule in these families for an excess of deformed individuals to show itself in the first generation, and this is the case also with the majority of deformities of the hands or feet which run through long families†.

Lastly if Mendelian proportions are to hold good they must not only hold good in every family of the particular deformity examined, *but they must above all hold good for each succeeding generation*, for upon this depends entirely the question of stability, which is the chief point at issue. In families showing split-foot the following figures are shown:—

	Parker & Robinson's		Ours		Fotherby's		Mayer's			
	D.	N.	D.	N.	D.	N.	D.	N.	D.	N.
1st gen.‡ ...	1	6	1	0	1 ?	?	1 ?	?	—	—
2nd gen. ...	9	4	11	3	1 ?	?	6	0	27	7
3rd gen. ...	7	12	13	5	2	2+	5	6	27	25
4th gen. ...	—	—	17	22	9	3	1	0	27	25
5th gen. ...	—	—	1	2	4	5	—	—	5	7
Totals ...									86	64

D. = deformed, N. = normal.

An examination of these figures shows a decided tendency for the deformity to die out. In view of this and of the hyperdominance of the deformity as a whole, the evidence points to the conclusion, despite the apparent segregation, that the transmission of hereditary split-foot is not governed by Mendelian laws. We have not yet seen a family tree of fair proportions which shows this adherence to Mendelism*. The family trees given by Bateson tend to show the same diminution in the proportion of affected to non-affected offspring in succeeding generations. In concluding this paragraph it may be said that evidence has not yet been produced which warrants the statement that any human sport is transmitted along the lines of Mendelism.

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* A dominance which has already been noted by Bateson in many families.

† Families illustrating "latency," are not here considered.

‡ For convenience sake, the numbering of generations in this table does not correspond with that given in Fig. 1.

Passing back to the original question, we find that the evidence of stability which Mendelism might have given is not forthcoming and that when the figures are taken on their own merit, they uphold the view expressed by Weismann that swamping of transmitted sports will eventually take place. As Weismann stated for polydactyly, that no family deformity has been traced through six generations, so might the same statement be made for hereditary split-foot, but the statement of Weismann no longer holds good† and there is no reason to disbelieve that the deformity of the "G" family will assert itself for several if not many more generations.

Given the factor of inbreeding a split-foot race might quickly arise. In this connection the family quoted by Windle after Devay is of interest (*Linnean Soc. Trans.*), for it shows the development of a polydactylous race in an isolated village.

Deformities may die out in one of several main ways. The deformity may be so gross as to render life impossible. Lesser grades of malformation though compatible with extrauterine life may predispose to early death, or handicap the individual in obtaining the necessaries of life. Other deformities, from their tendency to disfigure, may hinder mating. Others may render procreation impossible. Of these none, so far as can be seen, influence to any extent the prolificacy of individuals suffering from hereditary defects of the digits. In Devay's family there appears, upon the introduction of new blood, to have been a gradual diminution in the severity of the individual lesions as they passed through succeeding generations. The same tendency was considered by Fotherby and Mayer to be present in their families, but the evidence in these last cases is inconclusive. The extermination of hereditary split-foot takes place by a proportionate decrease in the number of deformed offspring, arising from deformed parents, from one generation to the next. To what this diminution is due is a question to which at present no answer is forthcoming, but the fact as it stands is directly opposed to the supposition that human sports or their originating factors may be regarded as unit characters, transmitted along those definite lines which certain natural characters in animals have been shown to be inherited.

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* Though we have searched a large number.

† Families of eight generations have been reported.

Summary and Chief Conclusions.

1. A family containing 44 deformed members is placed on record. Of these 17 are described in detail.

2. Of the many varieties of split-hand and split-foot, one is most prominent and is of sufficiently common occurrence to merit the name "hereditary split-foot." A general account of it is given and reasons assigned for considering it a deformity *sui generis.*

3. It usually affects the four extremities and shows great variability in all families in which it occurs. The types of deformity of the hands and feet are discussed and their relationship shown in different individuals and in separate families.

4. All the cases of symmetrical split-foot, which have been found, have been included in the bibliography. Of these over 167 occur in families in which other members are similarly affected; the remaining 13 are isolated. Nevertheless there is reason to believe that they are all of the same nature.

5. The deformity consists mainly of an ectrodactyly, but is frequently associated with various grades of syndactyly and polydactyly.

6. The deformity has its origin in a "sport," which takes place in the parental germ cells or their precursors, probably in the latter.

7. A plausible hypothesis is advanced in explanation of the quadruple nature of the sport and its tendency to recurring variation. It is supposed that the mutation originally occurs in that factor in the gametic cell (or its precursor) of the parent which governs the general and eventual conformation of the hands and feet, and that this mutation is transmitted as such. The succession of split-foot members in a family is consequently regarded as due to the transmission of a tendency to sport along definite lines.

8. It is probable that nature's sports occur in definite directions.

9. The transmission of "hereditary split-foot" does not follow the laws of Mendel. It is true that the deformity segregates, but it appears to a diminishing extent in succeeding generations. It shows no tendency to skip generations.

10. It remains to be shown that this or any other human sport is permanently stable, or strictly follows Mendelian laws.

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EXPLANATION OF PLATES.

Plate I. Fig. 1. Genealogical tree of the "G" family.

The following signs are used:—

The horizontal lines are drawn from parent to parent.
The oblique lines are drawn from parents to offspring.
The wavy lines indicate uncertainty of order of birth.
Black represents deformity, each quadrant of the circle representing the corresponding limb.
The shaded circles are instances of doubtful deformity.
The arrows when present indicate sex.
M. signifies a miscarriage. S.P. = died without offspring. D. = diseased. Illeg. = illegitimate.
Generation III, groups 3 and 4 represent 9 deformed and 2 normal offspring.
In generation V, 33 and 34 are twins and the circles are joined by a single horizontal line.

Plate II. Figs. 4 and 5. Photographs of the hands and feet of R. E. G. (Fig. 1, V, 41). The photographs show typical examples of the deformity in its external configuration.

Plate III. Figs. 6—9. Left hand, right hand, left foot and right foot respectively of R. E. G. (V, 41). Note the symmetry.

Plate IV. Figs. 10 and 11. Left and right hand of M. A. (IV, 17). Figs. 12 and 13. Left and right hand of E. M. G. (V, 40).

Plate V. Fig. 14. Right hand of L. V. G. (V, 45). Fig. 15. Right foot of E. M. G. (V, 40). Fig. 16. Left foot of M. A. (IV, 17). Fig. 17. Left hand of W. H. A. (V, 24); note that all skiagrams with this exception are taken from the dorsal aspect.

Plate VI. Figs. 18 and 19. Left and right hand of J. T. G. (V, 42). Figs. 20 and 21. Left and right foot of L. V. G. (V, 45).

Plate VII. Figs. 22 and 23. Left and right hand of E. G. (IV, 23). Figs. 24 and 25. Left and right foot of J. T. G. (V, 42).

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* Certain of these authors give isolated cases of split-foot, but they are apparently taken from sources already referred to.

ON THE GENERALISED PROBABLE ERROR IN MULTIPLE NORMAL CORRELATION.

By KARL PEARSON, F.R.S., and ALICE LEE, D.Sc.

The normal correlation surface in the case of n variables is known to be:

$$z = \frac{N}{(2\pi)^{\frac{1}{2}n}\,\sigma_1\sigma_2 \ldots \sigma_n \sqrt{R}}\, e^{-\frac{1}{2R}\{S(R_{pp}x_p^2/\sigma_p^2) + 2S'(R_{pq}x_px_q/\sigma_p\sigma_q)\}},$$

where
$$R = \begin{vmatrix} 1, & r_{12}, & r_{13}, & \ldots & r_{1n} \\ r_{21}, & 1, & r_{23}, & \ldots & r_{2n} \\ \ldots & \ldots & \ldots & \ldots & \ldots \\ \ldots & \ldots & \ldots & \ldots & \ldots \\ r_{n1}, & r_{n2}, & r_{n3}, & \ldots & 1 \end{vmatrix}$$

and R_{pq} is the minor corresponding to the constituent r_{pq}. S denotes a sum for all values of p from 1 to n, and S' a sum for every pair of unlike p, q's. x_p is the pth variate measured from its mean, σ_p its standard deviation and r_{pq} the correlation coefficient of the pth and qth variates.

Let
$$\chi^2 = \frac{1}{R}\{S(R_{pp}x_p^2/\sigma_p^2) + 2S'(R_{pq}x_px_q/\sigma_p\sigma_q)\}.$$

Then $\chi^2 =$ a constant, is the equation to an ellipsoid in n-fold space. If transferred to its principal axes, it will take the form

$$\chi^2 = \overset{n}{\underset{1}{S}}(X_p^2/\Sigma_p^2).$$

Further: $z\,dx_1dx_2 \ldots dx_n$ will equal

$$\frac{N}{(2\pi)^{\frac{1}{2}n}}\frac{1}{\Sigma_1\Sigma_2 \ldots \Sigma_n}e^{-\frac{1}{2}\chi^2}dX_1dX_2 \ldots dX_n,$$

representing the frequency due to n independent variates.

The ellipsoid in n-fold space can be reduced to a sphere by proper squeezes in the directions of its principal axes, and accordingly its volume can be found from that of a sphere in n-fold space. The volume of a sphere in n-fold space

$$=\frac{2^n a^n (\sqrt{\pi})^n}{1.2.3\ldots\frac{1}{2}n}, \text{ if } n \text{ be even,}$$

$$=\frac{2^{\frac{1}{2}(n+1)} a^n (\sqrt{\pi})^{n-1}}{1.3.5\ldots n}, \text{ if } n \text{ be odd.}$$

Hence the volume of an ellipsoid in n-fold space

$$=\frac{2^n a_1 a_2 a_3 \ldots a_n (\sqrt{\pi})^n}{1.2.3\ldots\frac{1}{2}n}, \text{ if } n \text{ be even,}$$

$$=\frac{2^{\frac{1}{2}(n+1)} a_1 a_2 a_3 \ldots a_n (\sqrt{\pi})^{n-1}}{1.3.5\ldots n}, \text{ if } n \text{ be odd.}$$

Applying these to our special cases we have for the volume of correlation ellipsoid, V:

$$V=\frac{2^n \Sigma_1\Sigma_2\ldots\Sigma_n \chi^n (\sqrt{\pi})^n}{1.2.3\ldots\frac{1}{2}n}, \text{ if } n \text{ be even,}$$

$$=\frac{2^{\frac{1}{2}(n+1)} \Sigma_1\Sigma_2\ldots\Sigma_n \chi^n (\sqrt{\pi})^{n-1}}{1.3.5\ldots n}, \text{ if } n \text{ be odd.}$$

Thus for the two cases:

$$\delta V=\frac{2^n \Sigma_1\Sigma_2\ldots\Sigma_n\, n\chi^{n-1}\,\delta\chi\, (\sqrt{\pi})^n}{1.2.3\ldots\frac{1}{2}n} \quad (n \text{ even}),$$

and

$$=\frac{2^{\frac{1}{2}(n+1)} \Sigma_1\Sigma_2\ldots\Sigma_n\, n\chi^{n-1}\,\delta\chi\, (\sqrt{\pi})^{n-1}}{1.3.5\ldots n} \quad (n \text{ odd}).$$

Now the total amount of frequency between two contour ellipsoids is $z\delta V$, and accordingly the frequency inside a given contour ellipsoid χ is given by:

$$I_\chi=\int_0^\chi z\,dV=\frac{N}{2.4.6\ldots n-2}\int_0^\chi e^{-\frac{1}{2}\chi^2}\chi^{n-1}\,d\chi, \text{ for } n \text{ even,}$$

$$=\sqrt{\frac{2}{\pi}}\,\frac{N}{1.3.5\ldots n-2}\int_0^\chi e^{-\frac{1}{2}\chi^2}\chi^{n-1}\,d\chi, \text{ for } n \text{ odd.}$$

Let

$$\mu_n(x)=\frac{1}{\sqrt{2\pi}}\int_0^x x^n e^{-\frac{1}{2}x^2}\,dx$$

be defined as the "incomplete nth normal moment function." Then

$$I_\chi/N=\frac{\sqrt{2\pi}\,\mu_{n-1}(\chi)}{2.4.6\ldots n-2}, \text{ if } n \text{ be even,}$$

$$=\frac{2\mu_{n-1}(\chi)}{1.3.5\ldots n-2}, \text{ if } n \text{ be odd.}$$

Now I_χ/N is the chance of an observation falling inside the contour χ, and $1-I_\chi/N$ the chance of its falling in the fringe outside this contour.

We see accordingly that the chance of an outlying observation being reasonable or not,—the observation consisting of a complex of n variates,—can be readily found, if the incomplete normal moment functions have once been tabled, and the constants of the correlation surface be known. These incomplete normal moment functions serve a variety of purposes which will be developed in later papers. The present paper merely refers to the means they provide of determining the probability of any observation lying outside a given contour ellipsoid, i.e. there being any "fringe" beyond this value of χ.

In Table I. pp. 66, 67 the values of $m_n(x)$

$$= \mu_n(x) / \{(n-1)(n-3)(n-5)\ldots 1\}, \text{ if } n \text{ be even,}$$

and

$$= \mu_n(x) / \{(n-1)(n-3)(n-5)\ldots 2\}, \text{ if } n \text{ be odd,}$$

are tabled for values of x from 0 to 5 proceeding by tenths. They were calculated in the following manner. Let

$$q_n = \sqrt{\frac{2}{\pi}} \int_x^\infty e^{-\frac{1}{2}x^2} dx + \sqrt{\frac{2}{\pi}} e^{-\frac{1}{2}x^2} \left\{ \frac{x}{1} + \frac{x^3}{1.3} + \frac{x^5}{1.3.5} + \ldots + \frac{x^{n-1}}{1.3.5\ldots n-1} \right\}, \text{ if } n \text{ be even,}$$

$$q_n' = e^{-\frac{1}{2}x^2} \left\{ 1 + \frac{x^2}{2} + \frac{x^4}{2.4} + \ldots + \frac{x^{n-1}}{2.4.6\ldots n-1} \right\}, \text{ if } n \text{ be odd.}$$

Then:

$$m_n = \tfrac{1}{2}(1 - q_n), \text{ if } n \text{ be even,}$$

$$= \sqrt{\frac{1}{2\pi}} (1 - q_n'), \text{ if } n \text{ be odd.}$$

The even series involve the probability integral which was taken from Sheppard's Tables (*Biometrika*, Vol. I. p. 182). Consequently the even series may have an error of unity in the seventh figure. It is hoped that arithmetical blunders have been avoided, but the labour has been very considerable and some blunders may have escaped notice.

If we make $I_\chi / N = \frac{1}{2}$, we find the contour ellipsoid within which half the frequency lies. In other words an observation is as likely to lie inside as outside this contour ellipsoid. The corresponding value of χ may be spoken of as the "generalised probable error." Since the first 10 incomplete moment functions have been calculated it is possible to determine the generalised probable errors for 1 up to 11 variables. These are given in the table on the next page.

Of these, the first is very familiar. The second was first given in Bravais' classical memoir (*Mém. prés. par divers Savans Étrangers*, T. IX. 1846, pp. 255—332). The third professes to be given by Czuber, *Theorie der Beobachtungsfehler*, S. 404, but I do not agree with his results. The value 1·53817 was given by me in College Lectures in 1896. The remainder have, as far as I know, not hitherto been published, although they have been for a considerable time in use in my Biometrical Laboratory.

Table of Generalised Probable Errors.

Number of Variables	Probable Error
1	0·674,4898
2	1·177,4062
3	1·538,1667
4	1·832,1239
5	2·086,0146
6	2·312,5982
7	2·519,0869
8	2·710,0022
9	2·888,3962
10	3·056,4366
11	3·215,7402

The method of calculation was as follows: If n be even we have from the equations on p. 61:

$$m_{n-1} = \tfrac{1}{2}\frac{1}{\sqrt{2\pi}} = \cdot 1994711.$$

If n be odd: $$m_{n-1} = \tfrac{1}{4} \qquad = \cdot 25,$$

since $I_\chi/N = \frac{1}{2}$.

The problem therefore resolves itself into an interpolation in the tables. Let y be the required argument of the table and x the corresponding value of m_{n-1}; let x_0, x_1, be the two values in the table immediately below x, and x_2, x_3 immediately above x; then the formula

$$y = y_2 + \tfrac{1}{10}\left\{-\frac{2(x-x_1)(x-x_2)(x-x_3)}{(x_0-x_1)(x_0-x_2)(x_0-x_3)} - \frac{(x-x_0)(x-x_2)(x-x_3)}{(x_1-x_0)(x_1-x_2)(x_1-x_3)} - \frac{(x-x_0)(x-x_1)(x-x_2)}{(x_3-x_0)(x_3-x_1)(x_3-x_2)}\right\}$$

was used to find y, i.e. a cubical parabola was passed through the four points. The accuracy of a variety of other interpolation formulae was found to be less.

Having found the values of the first eleven probable errors, an empirical formula was then sought which would closely express them, and which accordingly might be used for extrapolation. The form of curve finally adopted was that found by adding the ordinates of a line to that of a logarithmic curve. Its equation, after the adjustment of its constants by the method of least squares, was:

$$\text{P.E.} = -\cdot 067{,}769 + \cdot 071{,}986n + 2\cdot 308{,}272 \log_{10}(\cdot 994{,}484 + n),$$

giving the probable error in terms of the number of correlated variables n.

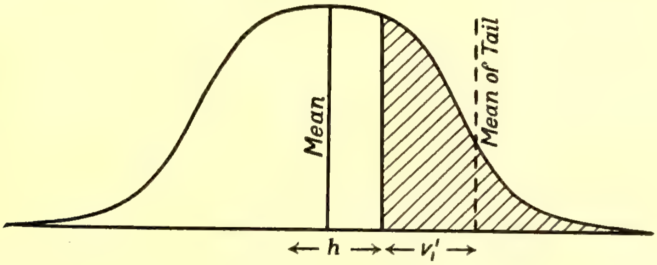
Of course we must not expect such an arbitrary formula to be true to more than some four figures. As a matter of fact in fitting it only the values from 3 to 11 were taken. The following give the calculated and actual values:

n	Calculated*	Actual
1	·696	·674
2	1·176	1·177
3	1·537	1·538
4	1·832	1·832
5	2·087	2·086
6	2·314	2·313
7	2·520	2·519
8	2·710	2·710
9	2·888	2·888
10	3·055	3·056
11	3·215	3·216
12	3·367	—
13	3·513	—
14	3·654	—
15	3·791	—

It appears accordingly probable that our formula up to possibly $n=15$ or more will represent the probable error with not more than ·001 error. The extreme divergence for the case of $n=1$ is noteworthy, and seems to place this result on a different footing to the others. The general agreement is shown graphically in the diagram on p. 64.

The general use of the table provided will be obvious, it enables us to tell the probability of any outlying individual really being a member of a population of which the constants are known. Thus one may look forward to the day when the biometric constants of a race being sufficiently well known, it may be possible to tell from a complex of five or six characters whether a skeleton or a skull may be reasonably supposed to have belonged to a member of that race. At present the labour of calculating the correlation coefficient-determinants and their minors stands in the way of much work in this direction, when we wish to advance beyond two or three characters.

The incomplete normal moment functions provide us with a method of determining, theoretically at least, the constants of a truncated normal distribution. The method is as follows. Let N be the total frequency, σ the standard



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* For plotting the curve we have also the ordinates ·3710, ·0276, −·0733 for $n=\frac{1}{2}$, 0·1, 0, respectively.

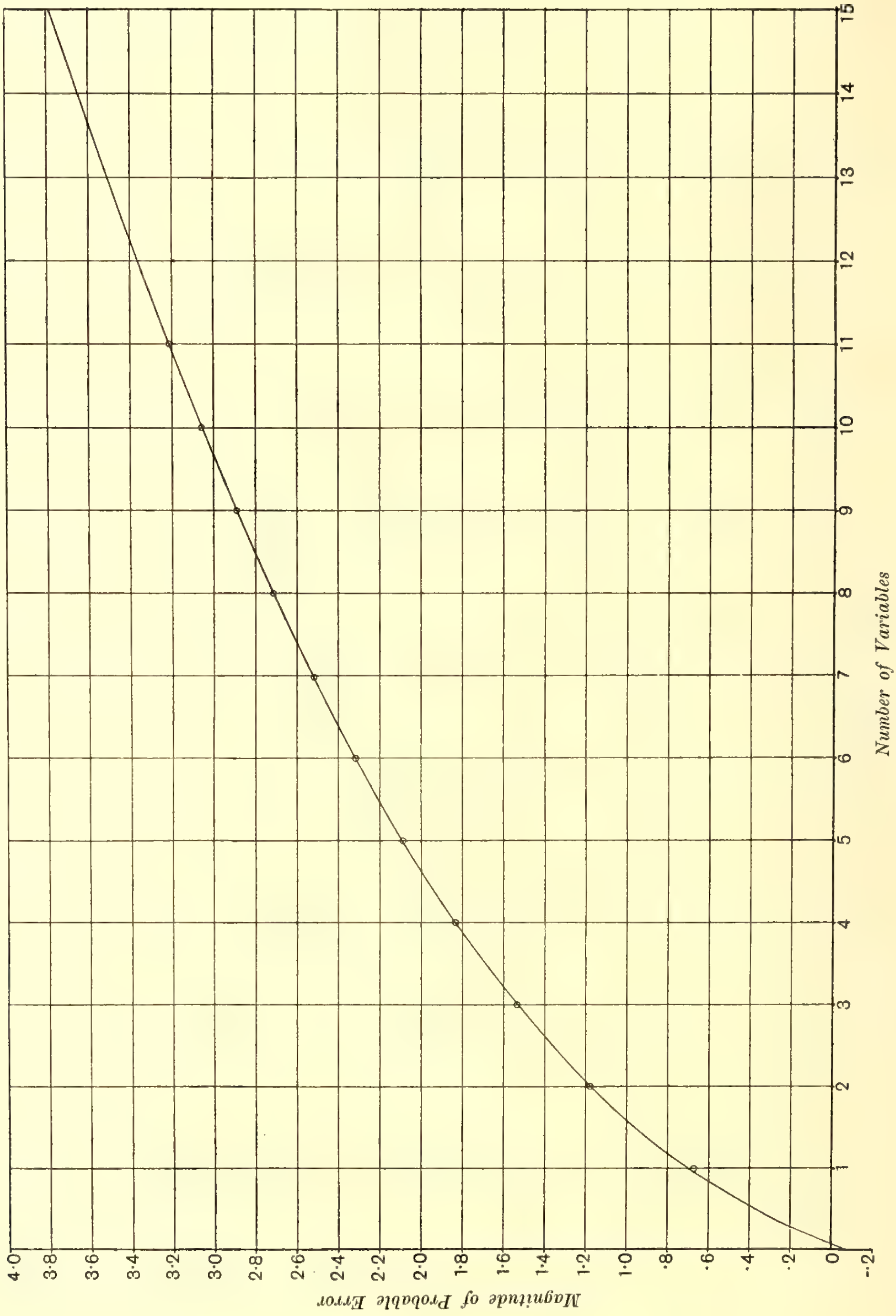


Diagram for value of probable error for n Variables.

deviation, and h the distance from the mean at which the distribution is truncated. Then the frequencies of the shaded part are known, but N, h and σ are unknown. Let n be the known total frequency of the tail, ν_1' the distance of its centroid, or mean, from the 'stump,' ν_2' the second moment of the tail about the stump, and Σ the standard deviation of the tail, of course about its mean; then ν_1' and ν_2' (or $\Sigma = \sqrt{\nu_2' - \nu_1'^2}$), are known from the observations.

Now $n\nu_p'$ is the pth moment of the tail about its stump and

$$n\nu_p' = \frac{N}{\sqrt{2\pi}\,\sigma}\int_h^\infty e^{-\frac{1}{2}\frac{x^2}{\sigma^2}}(x-h)^p\,dx$$

$$= \frac{N\sigma^p}{\sqrt{2\pi}}\int_{h'}^\infty e^{-\frac{1}{2}x'^2}(x'-h')^p\,dx', \text{ if } x' = x/\sigma,\ h' = h/\sigma,$$

$$= N\sigma^p\left(\mu_p(h') - ph'\mu_{p-1}(h') + \frac{p(p-1)}{1\,.\,2}h'^2\mu_{p-2}(h') - \text{etc.}\right),$$

where $\mu_p(h')$ is the incomplete normal moment function of the pth order. Representing it by μ_p' for brevity, we have

$$n = N\mu_0', \quad n\nu_1' = N\sigma(\mu_1' - h'\mu_0'),$$

$$n\nu_2' = N\sigma^2(\mu_2' - 2h'\mu_1' + h'^2\mu_0').$$

Hence we find

$$\Sigma^2/\nu_1'^2 = \psi_1 = (\nu_2' - \nu_1'^2)/\nu_1'^2 = (\mu_2'\mu_0' - \mu_1'^2)/(\mu_1' - h'\mu_0')^2 \ldots\ldots\ldots\ldots(1).$$

Now ψ_1 is a known quantity, being the ratio of the squared standard deviation of the tail to the squared distance of its mean from the stump. Accordingly if the value of ψ_1 be tabled to each h', then,—μ_0' being known from a table of the probability integral, and μ_1' and μ_2' from tables of the incomplete normal moment functions—we shall be able to find h' from the known value of ψ_1.

In the next place: $$N = n/\mu_0' \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

will be known from the probability integral table of μ_0' as soon as h' is known.

Lastly: $$\sigma = \nu_1'\mu_0'/(\mu_1' - h'\mu_0') = \nu_1'\psi_2 \ldots\ldots\ldots\ldots\ldots\ldots(3).$$

Or, if $\psi_2 = \mu_0'/(\mu_1' - h'\mu_0')$ be tabled for values of h', σ will be given at once in terms of ν_1'. Then $h = h'\sigma$ is determined, and the constants of the complete normal distribution found from the constants for the truncated tail.

We require accordingly tables of ψ_1 and ψ_2. It was found impossible to calculate these with sufficient accuracy from the usual 7-figure tables of the probability integral and the new tables of the normal moment functions. When h' gets at all considerable ψ_1 and ψ_2 depend on the differences of very small quantities. Accordingly μ_1' and μ_2' were calculated *de novo*, and owing to the kindness of Mr Sheppard an unpublished 9-figure table of the probability integral calculated by him was used. Even thus, it has not been considered desirable to give the table to more than three decimal figures.

TABLE I. *Values of the Incomplete Normal Moment Function* $\mu_n(x)$.

A. *Odd Moments* $m_n(x) = \mu_n(x)/\{(n-1)(n-3)(n-5)\ldots 2\}$.

x	$m_1(x)$	$m_3(x)$	$m_5(x)$	$m_7(x)$	$m_9(x)$
0·0	·0000000	·0000000	·0000000	·0000000	·0000000
0·1	·0019897	·0000050	·0000000	·0000000	·0000000
0·2	·0078996	·0000787	·0000005	·0000000	·0000000
0·3	·0175545	·0003920	·0000059	·0000001	·0000000
0·4	·0306721	·0012105	·0000321	·0000006	·0000000
0·5	·0468770	·0028688	·0001183	·0000037	·0000001
0·6	·0657177	·0057372	·0003390	·0000151	·0000005
0·7	·0866883	·0101861	·0008146	·0000493	·0000024
0·8	·1092507	·0165494	·0017172	·0001350	·0000086
0·9	·1328570	·0250925	·0032702	·0003242	·0000259
1·0	·1569716	·0359862	·0057399	·0006988	·0000687
1·1	·1810901	·0492895	·0094199	·0013795	·0001634
1·2	·2047562	·0649423	·0146092	·0025293	·0003549
1·3	·2275737	·0827672	·0215865	·0043539	·0007135
1·4	·2492148	·1024819	·0305828	·0070957	·0013414
1·5	·2694247	·1237174	·0417570	·0110219	·0023776
1·6	·2880214	·1460428	·0551764	·0164068	·0040005
1·7	·3048932	·1689923	·0708039	·0235098	·0064248
1·8	·3199921	·1920929	·0884945	·0325513	·0098944
1·9	·3333265	·2148899	·1080009	·0436894	·0146688
2·0	·3449513	·2369694	·1289874	·0569995	·0210055
2·1	·3549587	·2579749	·1510502	·0724606	·0291380
2·2	·3634677	·2776192	·1737425	·0899486	·0392533
2·3	·3706152	·2956902	·1966019	·1092390	·0514703
2·4	·3765478	·3120515	·2191769	·1300173	·0658224
2·5	·3814140	·3266380	·2410506	·1518971	·0822459
2·6	·3853593	·3394489	·2618602	·1744437	·1005767
2·7	·3885213	·3505370	·2813106	·1972006	·1205553
2·8	·3910268	·3599983	·2991823	·2197160	·1418391
2·9	·3929897	·3679593	·3153329	·2415682	·1640231
3·0	·3945104	·3745671	·3296946	·2623860	·1866637
3·1	·3956755	·3799784	·3422662	·2818638	·2093055
3·2	·3965582	·3843517	·3531029	·2997718	·2315079
3·3	·3972197	·3878403	·3623049	·3159582	·2528687
3·4	·3977101	·3905878	·3700046	·3303476	·2730432
3·5	·3980696	·3927244	·3763548	·3429335	·2917571
3·6	·3983304	·3943653	·3815183	·3537687	·3088145
3·7	·3985175	·3956099	·3856585	·3629529	·3240979
3·8	·3986503	·3965425	·3889331	·3706199	·3375646
3·9	·3987436	·3972329	·3914881	·3769253	·3492376
4·0	·3988085	·3977378	·3934552	·3820351	·3591947
4·1	·3988530	·3981028	·3949499	·3861165	·3675554
4·2	·3988833	·3983635	·3960708	·3893304	·3744677
4·3	·3989037	·3985475	·3969007	·3918258	·3800964
4·4	·3989173	·3986759	·3975073	·3937367	·3846117
4·5	·3989263	·3987645	·3979452	·3951801	·3881809
4·6	·3989321	·3988248	·3982573	·3962557	·3909614
4·7	·3989359	·3988656	·3984770	·3970466	·3930967
4·8	·3989383	·3988927	·3986298	·3976205	·3947135
4·9	·3989398	·3989106	·3987348	·3980315	·3959207
5·0	·3989408	·3989222	·3988061	·3983221	·3968097
∞	·3989423	·3989423	·3989423	·3989423	·3989423

TABLE I.—(*continued*).

B. *Even Moments* $m_n(x) = \mu_n(x)/\{(n-1)(n-3)(n-5)\ldots 1\}$.

x	$m_2(x)$	$m_4(x)$	$m_6(x)$	$m_8(x)$	$m_{10}(x)$
0·0	·0000000	·0000000	·0000000	·0000000	·0000000
0·1	·0001325	·0000002	·0000000	·0000000	·0000000
0·2	·0010512	·0000084	·0000000	·0000000	·0000000
0·3	·0034951	·0000626	·0000008	·0000000	·0000000
0·4	·0081136	·0002572	·0000058	·0000001	·0000000
0·5	·0154298	·0007604	·0000270	·0000008	·0000001
0·6	·0258121	·0018200	·0000925	·0000037	·0000001
0·7	·0394585	·0037575	·0002588	·0000139	·0000006
0·8	·0563914	·0069507	·0006223	·0000437	·0000025
0·9	·0764632	·0118045	·0013297	·0001177	·0000086
1·0	·0993740	·0187171	·0025857	·0002812	·0000251
1·1	·1246965	·0280428	·0046525	·0006094	·0000658
1·2	·1519070	·0400559	·0078427	·0012160	·0001558
1·3	·1804203	·0549214	·0125028	·0022617	·0003386
1·4	·2096248	·0726741	·0189894	·0039577	·0006842
1·5	·2389164	·0932091	·0276408	·0065653	·0012964
1·6	·2677274	·1162835	·0387442	·0103869	·0023209
1·7	·2955511	·1415300	·0525059	·0157516	·0039494
1·8	·3219594	·1684803	·0690258	·0229926	·0064207
1·9	·3466134	·1965937	·0882796	·0324204	·0100147
2·0	·3692680	·2252921	·1101113	·0442938	·0150415
2·1	·3897700	·2539927	·1342371	·0587910	·0218224
2·2	·4080525	·2821413	·1602593	·0759866	·0306667
2·3	·4241237	·3092387	·1876903	·0958345	·0418437
2·4	·4380556	·3348616	·2159821	·1181613	·0555560
2·5	·4499695	·3586763	·2445598	·1426700	·0719132
2·6	·4600231	·3804450	·2728554	·1689546	·0909136
2·7	·4683965	·4000247	·3003387	·1965228	·1124320
2·8	·4752816	·4173616	·3265431	·2248263	·1362197
2·9	·4808719	·4324798	·3510842	·2532933	·1619132
3·0	·4853546	·4454679	·3736720	·2813629	·1890538
3·1	·4889053	·4564647	·3941138	·3085150	·2171145
3·2	·4916838	·4656432	·4123121	·3342962	·2455315
3·3	·4938321	·4731975	·4282552	·3583379	·2737379
3·4	·4954736	·4793298	·4420056	·3803672	·3011962
3·5	·4967130	·4842409	·4536843	·4002102	·3274261
3·6	·4976381	·4881218	·4634555	·4177877	·3520261
3·7	·4983205	·4911484	·4715111	·4331061	·3746880
3·8	·4988183	·4934784	·4780568	·4462441	·3952025
3·9	·4991771	·4952491	·4833001	·4573366	·4134583
4·0	·4994330	·4965779	·4874418	·4665592	·4294345
4·1	·4996133	·4975627	·4906683	·4741120	·4431886
4·2	·4997391	·4982835	·4931479	·4802063	·4548407
4·3	·4998258	·4988045	·4950279	·4850521	·4645574
4·4	·4998849	·4991766	·4964343	·4888500	·4725352
4·5	·4999247	·4994392	·4974729	·4917846	·4789861
4·6	·4999512	·4996222	·4982298	·4940207	·4841246
4·7	·4999688	·4997483	·4987744	·4957010	·4881574
4·8	·4999802	·4998342	·4991613	·4969464	·4912765
4·9	·4999876	·4998919	·4994326	·4978572	·4936544
5·0	·4999923	·4999303	·4996206	·4985144	·4954417
∞	·5000000	·5000000	·5000000	·5000000	·5000000

TABLE II.

Values of the Functions ψ_1 and ψ_2 required to determine the Constants of a Normal Frequency Distribution from the Moments of its Truncated Tail.

h'	ψ_1	ψ_2	h'	ψ_1	ψ_2
0·1	·588	1·311	1·6	·787	2·358
0·2	·605	1·371	1·7	·796	2·437
0·3	·622	1·432	1·8	·804	2·517
0·4	·638	1·495	1·9	·813	2·598
0·5	·653	1·560	2·0	·820	2·679
0·6	·668	1·626	2·1	·828	2·762
0·7	·682	1·693	2·2	·835	2·845
0·8	·696	1·762	2·3	·842	2·929
0·9	·709	1·833	2·4	·848	3·013
1·0	·722	1·904	2·5	·854	3·098
1·1	·734	1·977	2·6	·860	3·184
1·2	·746	2·051	2·7	·866	3·270
1·3	·757	2·126	2·8	·871	3·357
1·4	·767	2·202	2·9	·876	3·445
1·5	·777	2·280	3·0	·880	3·532

This is quite sufficient for practical purposes, for the difficulties of practice do not arise from the paucity of figures in this table, but from quite other considerations, now to be described. In the first place, when we have a truncated distribution like that indicated in the above figure, the group of maximum frequency is at one end of the distribution, and any variation in this frequency widely modifies not only Σ but ν_1'. Thus the probable error of random sampling in the "stump" group is very influential. Next, the frequency is almost certain to be given in definite ranges, and the correction of the raw moments for such a case with the maximum frequency group at the terminal is tedious even if it can yet be considered satisfactorily determined. Thus in actual statistics, I have found that truncating at different frequency groups much modifies the values of the unselected frequency constants. For these practical reasons no very great number of decimal places is needful in ψ_1 and ψ_2. I think, however, the tables may be of service in determining the constants of the untruncated distribution to a first approximation, especially if the final values of those constants be based on truncating at two or three points and averaging the results. Further they may serve to give the *first* idea of the root of the nonic required when we break up a distribution into two components, the constants of one component being indicated by the tail of the frequency on that side.

I have to thank Dr A. Lee for the laborious arithmetic involved in the preparation of the tables accompanying this paper.

A further use of the incomplete normal moment tables in evaluating the incomplete B- and Γ-functions will be considered in another paper.

ON INHERITANCE OF THE DEFORMITY KNOWN AS SPLIT-FOOT OR LOBSTER-CLAW.

BY KARL PEARSON, F.R.S.

(1) MY attention was drawn at the beginning of 1907 to the existence of a family in which "split-foot" or "lobster-claw" was an hereditary deformity. I was unaware at the time that Dr Thomas Lewis and Mr Dennis Embleton were at work on a much more elaborate study of the same subject based on quite different material, and when I did know I did not hand over my material to them, as I ought properly to have done, because I wanted to ascertain independently to what extent simple Mendelism really applied to an obviously inherited and fairly simple human deformity. I wanted to convince myself that Mendelism does or does not apply to such cases, by handling the material myself and investigating by all the means at my disposal the authenticity of the records. At the same time my readers will suffer from having nothing like the completeness of detail in my case which may be found in the earlier paper of this number.

The members of the family are scattered through an agricultural district some distance from London, and I could only afford the cost of bringing three members up to London for radiography. In this matter I must mention my deep indebtedness to Miss C. O. Stevens not only for much aid in following up the family history from the clue she first reported to me, but also for the arduous task of piloting the strangers through the sights of the Metropolis. To Dr Mackenzie Davidson I owe the further big debt that, in the interests of science, he gave up a large portion of his valuable time to preparing by stereoscopic radiography no fewer than 22 negatives of the feet and hands of these three individuals.

Only a few of these radiograms are reproduced in this paper, but the variety of positions taken, as well as the stereoscopic nature of the pictures, has enabled my colleague, Professor Thane, to give a very complete account of the hands and feet of these three individuals. The ever ready aid given by Professor Thane to biometric inquiry would be very inadequately expressed by a few lines of thanks in a single biometric memoir.

It would indeed be impossible from Professor Thane's account of these three cases to predict the precise nature of the deformity—the presence or absence of bones—in other members of the family who have not been radiographed. No great faith is to be put in the family record of the number of perfect fingers or toes possessed by dead or living members. The list given on pp. 74, 75 must only be trusted for such obvious and gross variations in the nature of the deformity as supernumerary digits or syndactylised fingers. The importance of the accurate description of each individual member, however desirable, is less, after the work of Messrs Lewis and Embleton; their memoir fairly indicates the range of types to be expected. These types are largely represented in the members of my family who have been more fully examined; there are certain additional types also. It is clear that what they and I are dealing with is an hereditary deformity of the hands and feet, with a definite, if remarkably wide, field of variation.

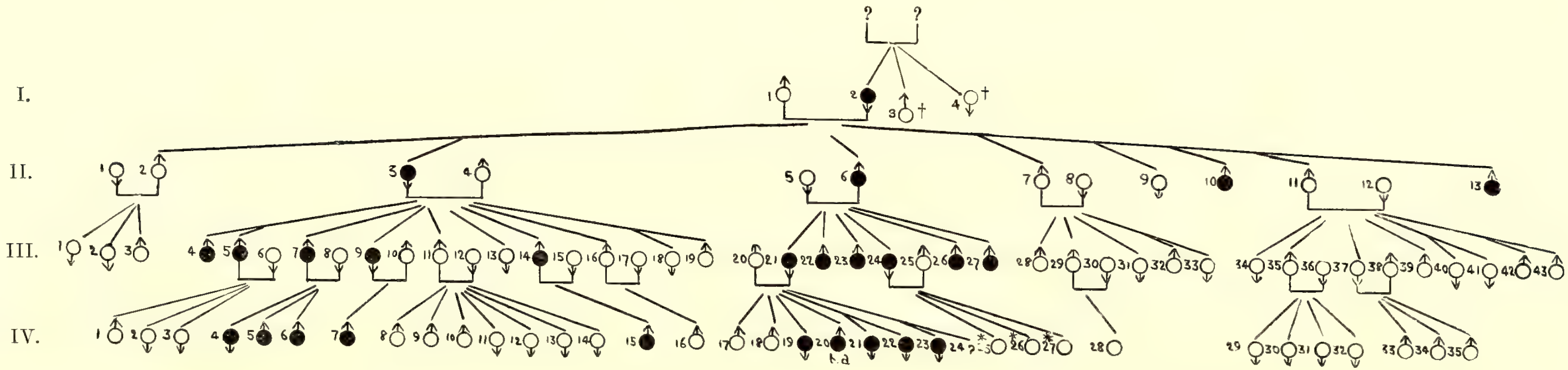
Lastly, I have most heartily to thank Mr J. H. Astbury, whose intimate knowledge of the district and its inhabitants has been most helpful to me in my inquiries.

(2) Before turning to more definite details as to the present family, I should like to mention the existence of a similar family, with names Bell and Agnew, at Whithorn, Wigtownshire, some 50 years ago. An old man told my informant that a boy with deformed hands was a descendant of the "Cleppie Bells." This was a family, one of which had assisted as Sheriff's officer at the drowning of the Wigton Bay martyrs in 1685. On that occasion the officer Bell said to a young maid, Margaret Wilson, "Will you not say: God bless King Charlie, and get this rope from off your neck?" "God bless King Charlie, if He will," she responded. Whereupon he said "Clep down among the partens and be drowned." Thus he was called "Cleppie Bell," and his descendants have ever afterwards suffered from a deformity of the hand, although sometimes a generation is missed over. It is true that the term "clepped" in Scotland refers to webbed, but the reference to the lobsters suggests "lobster-claw" deformity, and one phase of this, the syndactyly, might easily be described as fingers grown or webbed together. The boy referred to above became a sailor and was last seen in Glasgow 20 years ago. No stress whatever can be laid on such a tale as this, but it is interesting as pointing to the existence in Scotland[*] of a deformed hand inheritance for nearly two hundred years, and the information might be followed up by any one coming across Scottish cases of either webbed hands or lobster-claw. This is the only case I have met with in which there is any statement that deformed offspring were born from undeformed parents[†]. Throughout both my family and that of

[*] Messrs Lewis and Embleton state that their family originated in Scotland.

[†] This follows also from the somewhat different version given in Sir Andrew Agnew's *The Hereditary Sheriffs of Glasgow*, Edinburgh, 1893. We read in Vol. II. p. 142: "Still more grotesque is the tradition of the 'Cleppie Bells.' A constable who was held to have carried out his orders unfeelingly, as he fastened the women to the stakes, was asked how the poor creatures behaved when the cold wave roared and foamed about their heads. 'Oo,' he replied jocularly, 'they just clepped roun' the stobs like partens, and prayed.'—Soon after Bell's wife was brought to bed, when the howdie exclaimed in horror: 'The bairn is clepped!' (i.e. the fingers grew firmly together). Another child was born, and yet another, and as each little wretch in turn was seen to be 'clepped' the most incredulous were convinced it was a judgment of Providence.—We have been gravely assured that within the memory of man a female descendant of the bad constable on giving birth to a child, was horrified by the exclamation, 'The bairn is clepped.'"

FAMILY TREE. INHERITED "LOBSTER CLAW."



† No record of condition of I. 3 and I. 4.

* Died at birth, no record.

Messrs Lewis and Embleton undeformed members give rise only to undeformed offspring. It is not possible to say whether the deformity really is latent or not, there have been no cousin marriages to form even a rough test of latency.

The absence of cousin marriages of any kind compels us to consider "lobster-claw" as a dominant character, and after the ancestress I. 2 of my pedigree, who may in Mendelian terminology possibly have been a homozygote, all the descendants must be looked upon as heterozygotes. On this assumption all normal individuals are recessive, and the fact that normal individuals from tainted stocks do not have deformed offspring meets with a ready explanation.

It is this noteworthy point not only in the present family, but in Lewis and Embleton's family, in Drinkwater's Brachydactylous Family and in Nettleship's Night Blind Family, which is the main-stay in these cases of the Mendelian theory. It is perfectly true that it would flow from other hypotheses, for example from the assumption that the gamete was not pure, but that dominance flowed from a numerical preponderance of allogenic determinants*. Such a theory could only be tested by inbreeding. For the sake of science, therefore, if not for local well-being, it is desirable that marriages between the normal members of these stocks should occur, and this even in sufficient numbers to test whether there are really latent tendencies to the deformity in normal members of the stock. Should this not prove to be the case, the non-marriage of the deformed members would be sufficient to check the spread of the deformity. Obviously a determinantal theory not based upon the pure gamete would further account for the occasional and rare appearance of the deformity in a child of normal parents. Mendelism must assert in a case like the present where the character must be dominant, that such an appearance is a mutation or sport.

(3) Since the deformity must be looked upon as dominant in the Mendelian sense, it follows that on the average half the offspring of a deformed parent ought to be deformed. We have data for such families in three generations, and the following results flow from them:

N = Normal D = Deformed	Families										Totals	
	1		*2*		*3*		*4*		*5*			
	N.	D.	N.	D.	N.	D.	N.	D.	N.	D.	N.	D.
II. Generation	4	4	—		—		—		—		4	4
III. Generation	5	5	0	6	—		—		—		5	11
IV. Generation	0	3	0	1	0	1	2	5	3	0	5	10
Totals	—		—		—		—		—		14	25

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* See the paper in this number of *Biometrika* on p. 80.

The amount of material here is not very great, but, as far as it goes, it does not support the conclusion that for the tainted families the abnormal members are relative to the normal fewer in number. It seems rather to indicate that in the last generations the abnormal have been twice as numerous as the normal. My data are, however, far less numerous than Messrs Lewis and Embleton's. Leaving out their two doubtful cases, I find (*Biometrika*, Vol. VI. Plate I) that they have 32 normal to 43 abnormal members in the families of their stock with deformed parents. I shall confine my attention to their stock and my stock, because I feel in my own case the confidence of the personal collector, and am sure that a number of individuals have not been omitted or wrongly classed; and because I realise in their case also that Messrs Lewis and Embleton have examined their stock with the special view of testing definite ratios. The families of other observers may have been carefully worked out, but the importance of complete enumeration has only been recognised since it has become desirable to test Mendelian theory.

Examining the data from the statistical standpoint, I draw attention in the first place to the first family of the third generation. This family should approximate to 3 normal to 3 deformed, but every member born was deformed. The odds against a run of six deformed are 63 to 1, if the chances of normality and of lobster-claw are equal. The odds against a deviation as great as 25 to 14 from a ratio of equality are 14 to 1; the odds against Messrs Lewis and Embleton's ratio of 43 to 32 are about 9 to 1; the odds against such an excess as is represented by our combined results 68 to 46,—a ratio corresponding to 3 to 2 instead of 1 to 1,—are more than 49 to 1. Now this excess of the abnormal in any deformity like the present ought to be admitted, if it actually exists, for it is not only opposed to simple Mendelism, but its bearing on Eugenics is of the greatest importance. While I have found the like excess in other cases, it does not appear to be true for all deformities. Thus, from the pedigree plate in Mr Nettleship's admirable paper on Night Blindness*, I deduce the following results:

	Abnormal	Normal
Generation III.	10	6
Generation IV.	15	43
Generation V.	26	29
Generation VI.	30	51
Generation VII.	27	55
Generation VIII.	14	36
Generation IX.	9	11
Totals	131	231

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* *Ophthalmological Society's Transactions*, Vol. XXVII. pp. 269–291.

The odds against such a deviation from equality are enormous, i.e. about 10,000,000 to 1. But it will be noted that the abnormal members are largely in *defect.* Mr Nettleship himself remarks that this deficiency may probably be explained by unavoidable imperfections in the record, especially in the earlier generations. The excess of normals, however, has been more than maintained in the recent generations; and if, in defending the Mendelian ratio of equality, we impugn the record on the ground that members of the stock are ashamed to own their defect and screen it, what then becomes of the evidence it undoubtedly provides for Mendelian theory in the "invariable continuity of descent of the disease in the affected branches, and its permanent disappearance from all other divisions of the genealogy"? The screening of the disease must clearly have become an hereditary character, and the above evidence of segregation would be worthless. This principle of segregation is so vital, is such a wonderful, and I am inclined to say, glorious addition to our knowledge of heredity, that I am inclined in these cases of family abnormalities to defend Mendel against Mendel, or to preserve Mendelian segregation at the expense of Mendelian ratios. We have seen that the odds against a ratio of 3 to 2, which is the combined result of our split-foot families, are very slight, and this applies equally to the case of Night Blindness, where a random sample deviating as much as the present one from the ratio of 3 to 2 would occur once on the average in 6 or 7 trials. There is an additional point also to be noted. The Curé of Vendémean, according to Mr Nettleship, states that if the original night-blind individual, "the Jean Nougaret of 1637 could reappear to-day, except for a few individuals recently established in the district, all could salute him as their ancestor" (*loc. cit.* p. 288). If this be true, then the Mendelian ratio to be expected is more than 1 to 1, for the husband or wife of the night-blind individual would, in certain cases, be screening their own defect, and the offspring ought to have been night-blind in the ratio of 3 to 1. On the whole, while these cases give very definite evidence of the segregation factor, they do not seem to me to favour the segregation in rigid Mendelian proportions.

(4) When we turn to the actual nature of the deformity in the case I am dealing with, we find all the principal types observed by Messrs Lewis and Embleton recur, with one exception which may exist, but owing to the few individuals who have been radiographed, this cannot be asserted. I refer to the existence of cross bones (*Biometrika,* Vol. VI. p. 41). On the other hand, individuals exist showing syndactyly and polydactyly; gross deformity, several "fingers" placed promiscuously on a large misshapen "hand"; or branching fingers which, without careful radiographic examination, it would perhaps be hard to classify as polydactyle or misplaced.

The usual type of hand is to outward appearance, the hook-like form of my Plate XI, but the degree of defectiveness in the bones of the hand, even as affecting the carpus, may vary widely. In one case (II. 3) the hands were perfect but the feet deformed. There seems to be some evidence that in the younger generations the defectiveness is increasing; thus all the children of II. 6 had two-toed feet, but the children of III. 21 are one-toed, with one exception, who has one two-toed foot, and the other one-toed. In this family as distinct from that of Lewis and Embleton the defectiveness in the foot may reach the tarsus. Contractions of the fingers and toes, these being flexed towards the centre of the member, are common. The following is a rough external account of the deformity of the individuals in the pedigree:

List of deformed members of the Stock.

I. 2. Ann J. Nothing known of her parents; said to have had a brother and sister but no record of their condition to be found. She had one finger only to each hand, but the 1st and 5th toes on both feet. Died at 77. There was no consanguinity between I. 1 and I. 2.

II. 6. Two fingers on right hand, one finger and thumb on left; 1st and 5th toes on each foot. No consanguinity with wife II. 5. Cause of death, asthma.

II. 10, II. 13. Deformed, both hands and feet.

II. 3. Hands perfect, both feet only 1st and 5th toes. Husband II. 4 not related.

III. 21—24, 26, 27 are children of II. 6 above.

III. 21. One finger to each hand, and 1st and 5th toes. Subject to fits. Unrelated to husband, III. 20. See Plates XI, XII, XIII and XV, Fig. vii.

III. 22. Right hand six fingers, the supernumerary beyond the little finger; left hand five fingers, all deformed and bent at angles to palm of hand. 1st and 5th toes on each foot. Dead.

III. 23. Both hands one finger, both feet 1st and 5th toes. Diseased arm bone.

III. 24. Right hand ring and little fingers, but these united together; left hand two bent fingers and thumb. 1st and 5th toes on each foot.

III. 25. Right hand two fingers only; left hand two fingers and thumb; both feet 1st and 5th toes.

III. 26. One finger on each hand; 1st and 5th toes on each foot.

III. 4, 5, 7, 9 and 14 are children of II. 3. No details except that both hands and feet are affected.

In the fourth generation, we have first children of III. 21.

IV. 19. Both hands and feet affected; 5th toe only. Married, no offspring at present.

IV. 20. Both hands and feet affected; 5th toe only; stillborn.

IV. 21. Only 5th toe on each foot; little finger on each hand. Has had one or more fits. Plates XI, XIV and XV, Fig. viii.

IV. 22. Both hands and feet affected; 5th toe only; weakly constitution.

IV. 23. One finger on each hand. 1st and 5th toes on right foot, 5th toe only on left foot. See Plates XI and XVI.

IV. 24? Expected Birth*.

IV. 18 has also a weakly constitution though hands and feet are normal.

Of the descendants of II. 3, the grandchildren through III. 7 and III. 8 (who are unrelated) are:

IV. 4. Ring and little finger only, joined together on each hand. 1st and 5th toes on each foot.

IV. 5. One little finger only on each hand; 5th toe only on each foot.

IV. 6. One little finger only on right hand; thumb and little finger on left hand; 1st and 5th toes on each foot.

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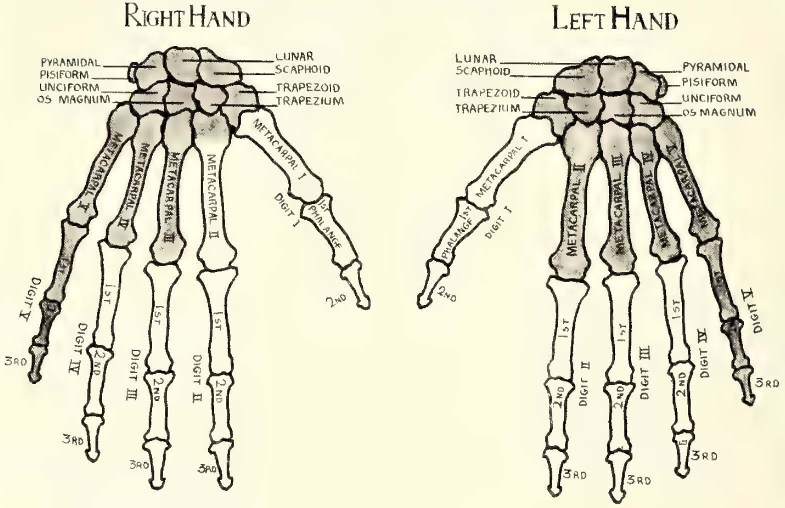
* Born as this proof goes finally to press; a girl deformed in both hands and feet. Thus the improbability of the Mendelian quarter is greater than that given above.

MOTHER'S HANDS.

III.1.


RIGHT HAND
LEFT HAND
PYRAMIDAL
PISIFORM
UNCIFORM
OS MAGNUM
LUNAR
SCAPHOID
TRAPEZOID
TRAPEZIUM
METACARPAL I
METACARPAL II
METACARPAL III
METACARPAL IV
METACARPAL V
1ST PHALANGE
DIGIT I
DIGIT II
DIGIT III
DIGIT IV
DIGIT V
1ST
2ND
3RD

ELDER DAUGHTER.

IV.3.

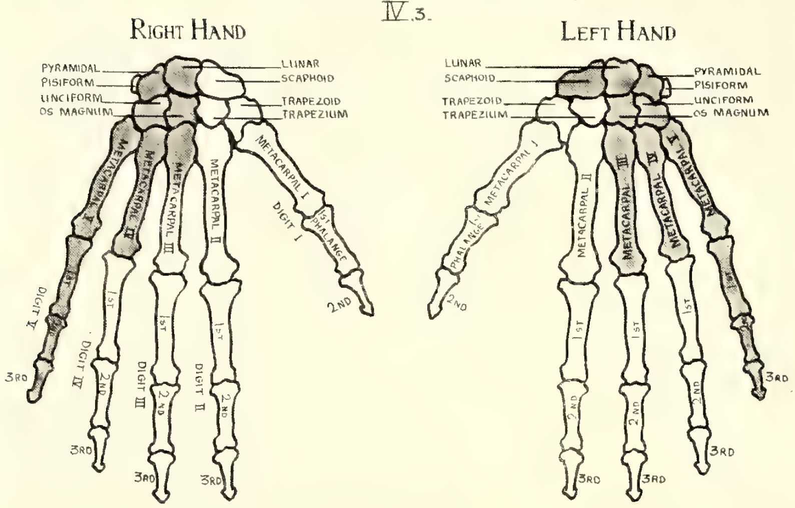
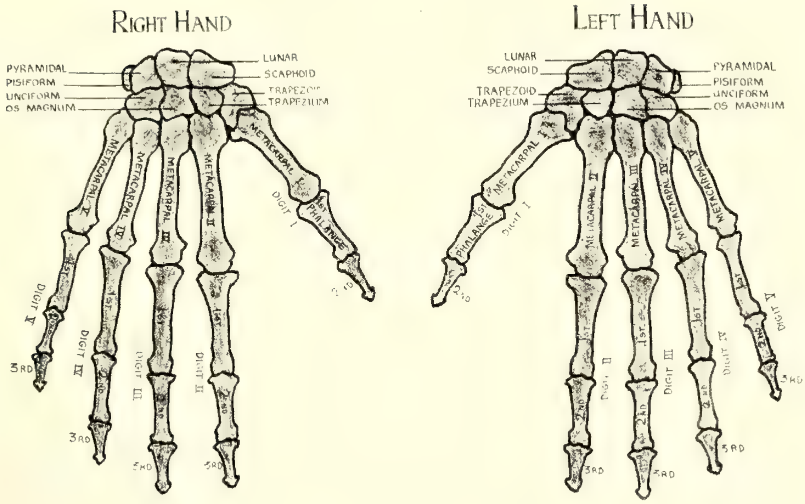

RIGHT HAND
LEFT HAND
PYRAMIDAL
PISIFORM
UNCIFORM
OS MAGNUM
LUNAR
SCAPHOID
TRAPEZOID
TRAPEZIUM
METACARPAL I
METACARPAL II
METACARPAL III
METACARPAL IV
METACARPAL V
1ST PHALANGE
DIGIT I
DIGIT II
DIGIT III
DIGIT IV
DIGIT V
1ST
2ND
3RD

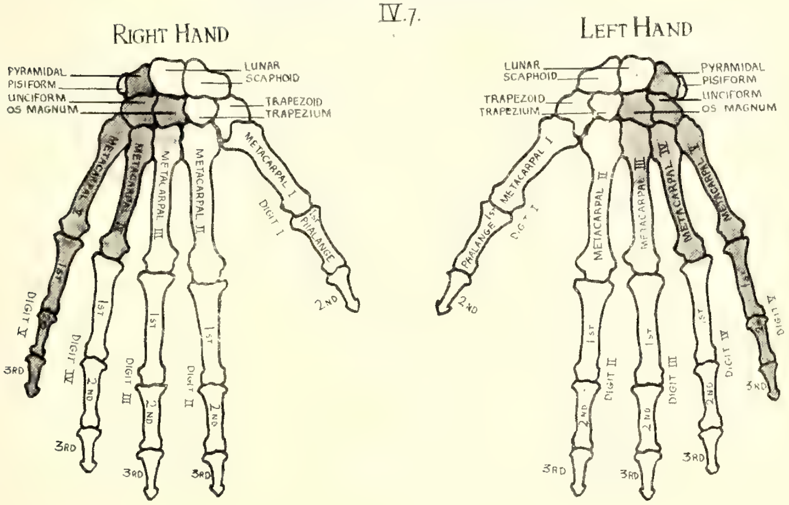
Plate IX

NORMAL HANDS.


RIGHT HAND
PYRAMIDAL
PISIFORM
UNCIFORM
OS MAGNUM
LUNAR
SCAPHOID
TRAPEZOID
TRAPEZIUM
METACARPAL I
METACARPAL II
METACARPAL III
METACARPAL IV
METACARPAL V
1ST PHALANGE
DIGIT I
2ND
DIGIT II
DIGIT III
DIGIT IV
DIGIT V
1ST
2ND
3RD
LEFT HAND
LUNAR
SCAPHOID
TRAPEZOID
TRAPEZIUM
PYRAMIDAL
PISIFORM
UNCIFORM
OS MAGNUM

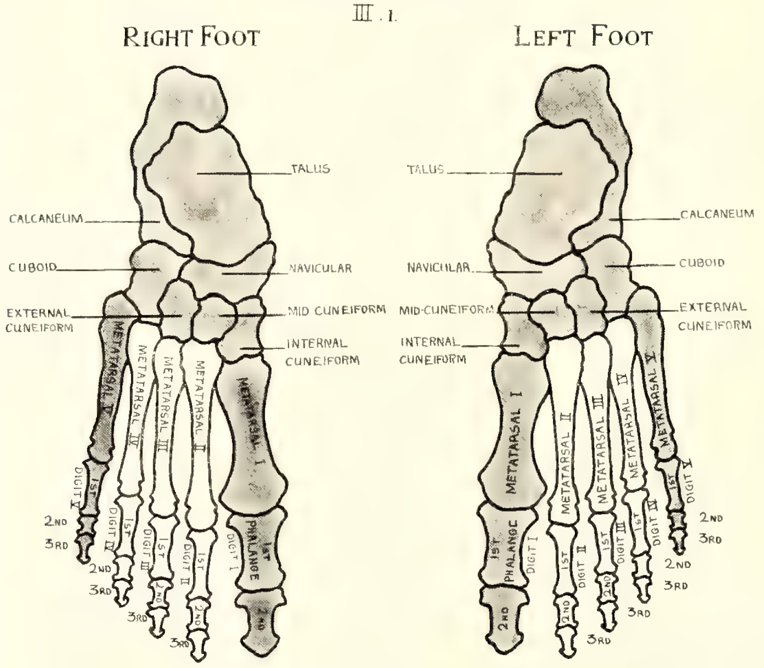
YOUNGER DAUGHTER.

IV.7.


RIGHT HAND
PYRAMIDAL
PISIFORM
UNCIFORM
OS MAGNUM
LUNAR
SCAPHOID
TRAPEZOID
TRAPEZIUM
METACARPAL I
METACARPAL II
METACARPAL III
METACARPAL IV
METACARPAL V
1ST PHALANGE
DIGIT I
2ND
DIGIT II
DIGIT III
DIGIT IV
DIGIT V
1ST
2ND
3RD
LEFT HAND
LUNAR
SCAPHOID
TRAPEZOID
TRAPEZIUM
PYRAMIDAL
PISIFORM
UNCIFORM
OS MAGNUM

MOTHER'S FEET.

III. 1.


RIGHT FOOT
LEFT FOOT
TALUS
CALCANEUM
CUBOID
NAVICULAR
EXTERNAL CUNEIFORM
MID CUNEIFORM
MID-CUNEIFORM
INTERNAL CUNEIFORM
METATARSAL I
METATARSAL II
METATARSAL III
METATARSAL IV
METATARSAL V
DIGIT I
DIGIT II
DIGIT III
DIGIT IV
DIGIT V
1ST PHALANGE
1ST
2ND
3RD

ELDER DAUGHTER.

IV. 3.

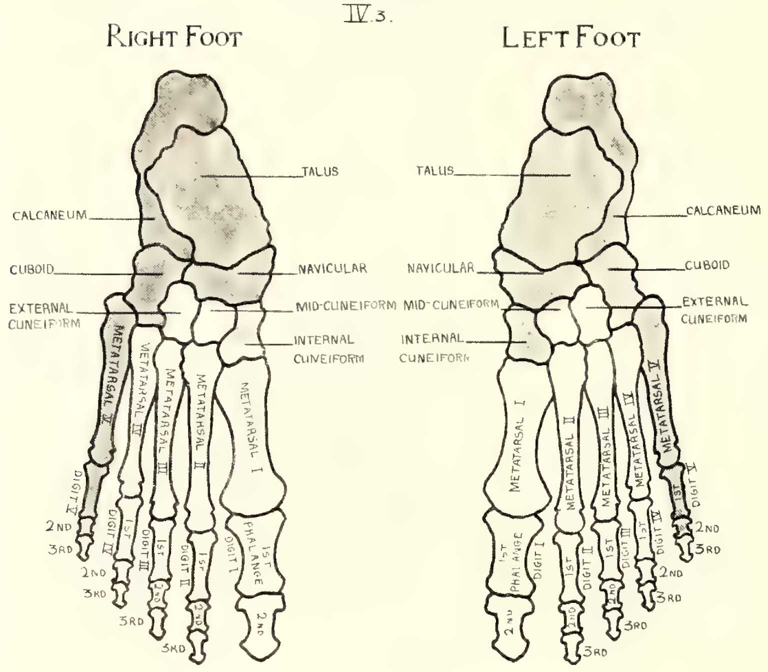
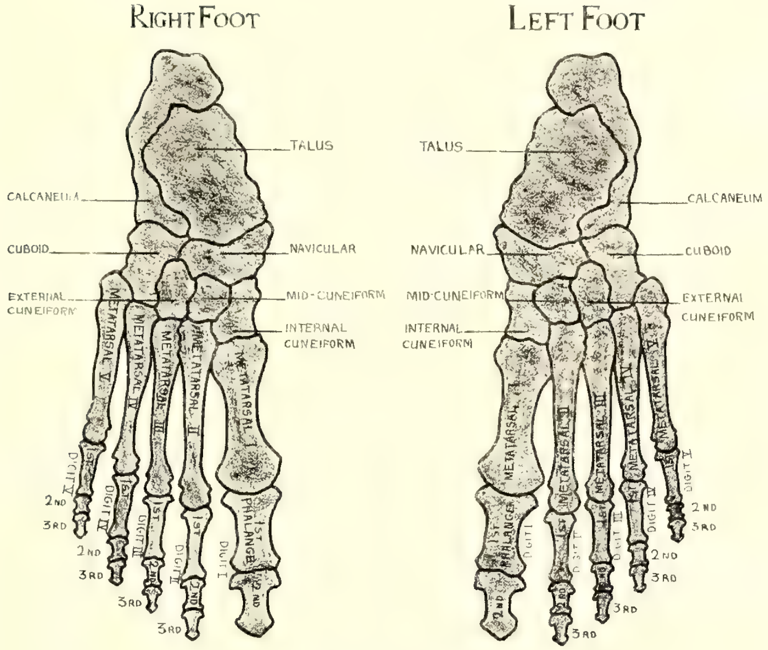

RIGHT FOOT
LEFT FOOT
TALUS
CALCANEUM
CUBOID
NAVICULAR
EXTERNAL CUNEIFORM
MID-CUNEIFORM
INTERNAL CUNEIFORM
METATARSAL I
METATARSAL II
METATARSAL III
METATARSAL IV
METATARSAL V
DIGIT I
DIGIT II
DIGIT III
DIGIT IV
DIGIT V
1ST PHALANGE
1ST
2ND
3RD

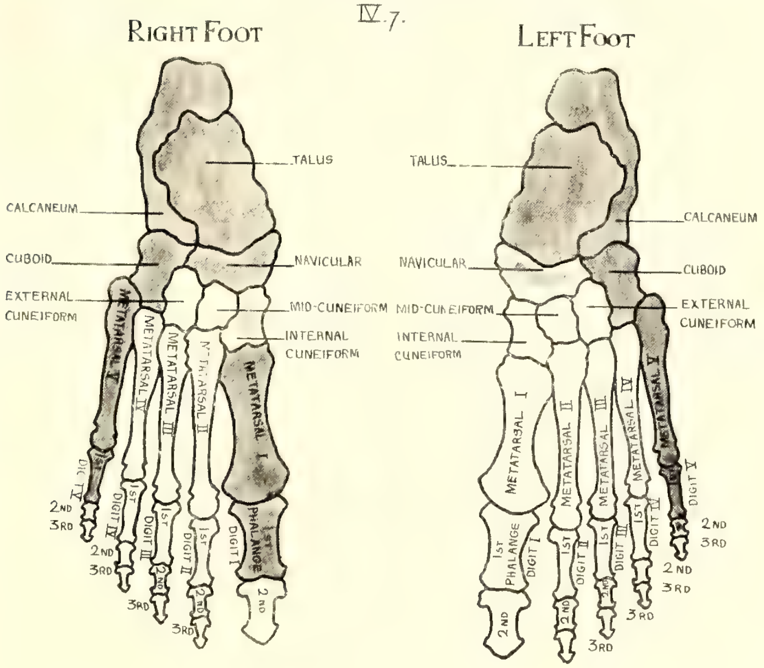
Plate X

NORMAL FEET.


RIGHT FOOT
LEFT FOOT
TALUS
CALCANEUM
CUBOID
NAVICULAR
EXTERNAL CUNEIFORM
MID-CUNEIFORM
INTERNAL CUNEIFORM
METATARSAL I
METATARSAL II
METATARSAL III
METATARSAL IV
METATARSAL V
DIGIT I
DIGIT II
DIGIT III
DIGIT IV
DIGIT V
1ST PHALANGE
1ST
2ND
3RD

YOUNGER DAUGHTER.

IV.7.


RIGHT FOOT
LEFT FOOT
TALUS
CALCANEUM
CUBOID
NAVICULAR
EXTERNAL CUNEIFORM
MID-CUNEIFORM
INTERNAL CUNEIFORM
METATARSAL I
METATARSAL II
METATARSAL III
METATARSAL IV
METATARSAL V
DIGIT I
DIGIT II
DIGIT III
DIGIT IV
DIGIT V
1ST PHALANGE
1ST
2ND
3RD

Of the other two grandchildren of II. 3, belonging to the deformed group, IV. 7 and IV. 15, I only know that both feet and hands are deformed.

Attention must be drawn to the fact that the deformed individual III. 5 has had three children all normal, and to the fact that the deformed individual III. 24 has had three children born dead, of whom nothing is known as to presence or absence of deformity.

(5) Of the three individuals III. 21 and her two daughters IV. 21 and IV. 23, aged respectively 10 and 2½ years, the following account has been drawn up by Professor Thane from Dr Mackenzie Davidson's radiograms. In the list below a plus sign marks the presence of the corresponding bone, the dot its absence. In the diagrams of Plates IX and X the defectiveness of the bones of the hands and feet is indicated by noting the presence of bones by shading in each case, the unshaded bones are absent, a key figure indicates the bones of the normal hand and foot*. These figures show nothing of the contracted and distorted form of the original members, for which the reader is referred to Plates XII to XVI which give a few of the radiograms of these three cases. It is fairly possible by the shadow of the fleshy parts and the aid of Plate XI to reach a reasonable appreciation of the actual appearance of the living individuals.

Hands	Mother III. 21 Age 37		Elder Daughter IV. 21 Age 10		Younger Daughter IV. 23 Age 2½	
	Right	Left	Right	Left	Right	Left
Scaphoid ...	+	+	•	+	•	•
Lunar ...	+	+	+	+	•	•
Pyramidal ...	+	+	+	+	+	+
Pisiform ...	+	+	•	•	•	•
Trapezium ...	+ ?	+	•	•	•	•
Trapezoid ...	+	+	•	•	•	•
Magnum ...	+	+	+ ?	+	+	+
Unciform ...	+	+	+	+	+	+
Metacarpal 1	•	•	•	•	•	•
" 2	+	+	•	•	•	•
" 3	+	+	+	+	+ ?	+
" 4	+	+	+	+	+	+
" 5	+	+	+	+	+	+
Digit 1	•	•	•	•	•	•
" 2	•	•	•	•	•	•
" 3	•	•	•	•	•	•
" 4	•	•	•	•	•	•
" 5	+ 3 ph.	+ 3 ph.	+ 3 ph.	+ 3 ph.	+ 3 ph.	+ 3 ph.

Feet	Mother III. 21		Elder Daughter IV. 21		Younger Daughter IV. 23	
	Right	Left	Right	Left	Right	Left
Calcaneum ...	+	+	+	+	+	+
Talus	+	+	+	+	+	+
Navicular ...	+	+	+	+	+	+
Intl. Cuneiform	+	+	+	+	+	•
Mid. Cuneiform	+	+ ?	•	•	•	•
Extl. Cuneiform	+	+	•	•	•	•
Cuboid ...	+	+	+	+	+	+
Metatarsal 1 ...	+	+	•	•	+	•
" 2 ...	•	•	•	•	•	•
" 3 ...	•	•	•	•	•	•
" 4 ...	•	•	•	•	•	•
" 5 ...	+	+	+	+	+	+
Digit 1 ...	+ 2 ph. fused	+ 2 ph.	•	•	+ 1 ph.	•
" 2 ...	•	•	•	•	•	•
" 3 ...	•	•	•	•	•	•
" 4 ...	•	•	•	•	•	•
" 5 ...	+ 3 ph.	+ 3 ph.	+ ? 2 ph.	+ 2 ph	+ 1 ph.	+ 2 ph. ?

The nature of the deformity in these limbs is a partial suppression of the digits, together with reduction (absence or fusion) of certain associated carpal or tarsal elements in the more pronounced cases. The bones of the forearm and leg are normal in their disposition as far as they appear in the photographs.

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* Owing to an oversight of the draughtsman, the names of the bones were inserted on *all* the figures; it seemed better to leave the redundancy than to go to the labour of redrawing the plates.

In the mother, III. 21, the left hand has a well-developed carpus which may be regarded as normal, while in the right hand the distal row of the carpus shows only three bones, the outermost of which probably represents the fused trapezoid and trapezium. In both hands the fifth digit (little finger) is well developed; the whole thumb is missing, as are also the phalanges of the index, middle and ring fingers, those digits being represented only by the metacarpal bones, of which the proper second (that of the index finger) is the smallest, and indeed in the right hand is reduced to a small piece of bone corresponding to the basal portion only of the normal bone.

In the left hand of the daughter, IV. 21, there are three bones in the proximal row of the carpus, the pisiform being as yet unossified, two only in the distal row, magnum and unciform, the three inner metacarpal bones, diminishing in size from the fifth to the third, and the normal three phalanges of the little finger. Suppressed are the two outer bones of the distal row of the carpus, trapezium and trapezoid, the first and second metacarpal bones, and the phalanges of the thumb, index, middle and ring fingers. The right hand shows a greater degree of reduction, the scaphoid being suppressed in the proximal row of the carpus, while in the distal row there is only one bone representing the fused magnum and unciform, and the third metacarpal is smaller than in the left hand.

IV. 23 has only three carpal bones, pyramidal, magnum and unciform, in each hand, but she is still too young for ossification to have started in the others; the fourth and fifth metacarpal bones are fairly well developed; the third metacarpal is small, in the right hand merely a nodular vestige of the basal portion; the phalanges of the little finger are present and of good size.

The malformation of the hands consists therefore of suppression or reduction of parts proceeding from the radial (thumb) side towards the ulnar (little finger) side, and carried to the greatest extent in the young child, IV. 23.

The feet are not so homogeneous as the hands, and fall into two well-marked groups. In the one, comprising the two feet of the mother and the right foot of the younger child, IV. 23, the three middle digits are suppressed, including metatarsal bones and phalanges, while the first and fifth are fairly well developed, especially in the mother. The tarsus may be regarded as complete in the mother, only in the right foot the number of elements is apparently reduced by the fusion of the internal and middle cuneiform bones; while in the right foot of IV. 23 the middle and external cuneiform bones are missing, but it may be that they are still in the cartilaginous stage, ossification not having yet begun.

The two feet of IV. 21 and the left foot of IV. 23, which constitute the second group, are also very much alike. Here the inner four digits are suppressed, and only the fifth (little) toe is represented. In all the talus, calcaneum and cuboid of the tarsus are well developed, the navicular is ossified (just beginning to ossify in

IV. 23)*, and the external and middle cuneiform are wanting, while a rudimentary internal cuneiform is present in both feet of IV. 21; that this is not seen in IV. 23 is again possibly due to delayed ossification.

Hence the second group differs from the first in the suppression also of the first digit, and probably a concomitant reduction of the tarsus. The close resemblance of the condition in this second group to that exhibited by the hands is obvious.

All through the deformity is greater in the children than in the mother.

In the hands, IV. 23, the younger daughter, shows greater degree of reduction than IV. 21. The small number of carpal bones in IV. 23 is to be explained however by the fact that the child is too young for ossification to have begun in the missing elements. The same consideration will account for the absence of the pisiform in IV. 21. This does not apply to the metacarpal bones.

In the feet there is a difference on the two sides. The left foot is slightly more reduced in IV. 23 than in IV. 21; whereas the right foot is much more defective in IV. 21, IV. 23 having the first digit fairly well developed.

In all three the right hand shows a greater degree of reduction than the left, expressed in the condition of the metacarpal bones.

In the mother the left foot may be regarded as being slightly more reduced, as indicated by the fusion of the internal and middle cuneiform bones. In IV. 21 the reduction is slightly greater in the right foot than in the left; whereas in IV. 23 the left foot is the most reduced of the whole series, while the right foot has a well developed metatarsal and phalanx to both great and little toes.

(6) I have delayed referring to my final criticism of the application of Mendelian conceptions to cases of abnormality like the present, until I had placed before the reader the above accurate account of the nature of the defect in two or three individuals. But having done so it seems to me that a very difficult question has to be answered. What in a case like this of split hand and foot is the Mendelian unit character? What are the allelomorphs whose combined absence or combined presence is impossible in the zygote? We can understand what is meant when an organ is said to be yellow or white, rough or smooth, however much we may wish for the use of a quantitative scale of such characters. We can understand what is meant by the presence or absence of a given individual bone, say the second phalanx of the fifth digit. But in a case like the present we are concerned not with a simple unit of any kind, but the absence of a complex of even as many as 60 bones situated in four different parts of the body. In other cases 10, 20 or 40 bones may be wanting or incompletely developed. It is true that these parts are highly correlated, but as we have seen, deformity of the feet is not always accompanied by deformity of the hands. Can we look upon the character here as built up of a series of coupled characters representing the system of bones we have referred to? If so, how can we explain the variety of detail which is to be found within the same family? How shall we account for other

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* It is interesting to the anatomist to note that the tuberosity of the navicular bone has a distinct centre of ossification in both feet of IV. 21.

families in which mere syndactyly or polydactyly occurs, or again in which club-foot alone is inherited? It appears to me that in a case like the present we cannot possibly speak of the presence or absence of a unit character, there must be an inertia or weakening of some development-controlling determinant. I will not venture to call it an absence of such a determinant, because its range varies so widely from individual to individual. If we use the word absence we must make the full control depend on the presence of a large number of units, and there must be—as for example in the reducing division—some process by which a random number of these are cast out. Even with this interpretation we are really thrown back on quantitative degrees in the controlling factor. These control units cannot be specific, for if they were associated with special bones, it is not easy to understand how a bone occurring in parent and grandparent* could disappear in the zygote resulting from a normal union. The problem has been forced on me recently from the practical side in studying cases of human degeneracy with correlated defects, and although I have thought over it carefully I can see no daylight theoretically in these questions of correlated physical or mental defects —defects having a considerable range of variation, but peculiar to certain stocks —except from the assumption of development-controlling units or determinants.

These determinants may be more or less definitely associated with certain portions of the body—hands and feet, or eyes for example—but the total number rather than any specific character of each must determine in every individual case the extent of defective development. Whatever the *modus* may be, i.e. whether the determinantal system be quantitatively continuous or consist of discrete units, I venture to suggest that it is rather in the direction of inertness in controlling determinants than in the hypothesis of a definite allelomorphic character in the Mendelian sense that we must seek for light on the inheritance of physical or mental degeneracy or deformity in man. The complexity and variety of the deformity in many of these cases is too great for us to attribute it to a single allelomorph, and there is thus no obvious reason for anticipating a simple Mendelian ratio.

(7) On the subjects of my present study a few general remarks may be made. They show remarkable aptitude in the use of their misshapen hands. At school the children hold their own with normal scholars in writing, drawing, and even needlework. The family rather resent anything in the shape of pity. One of its men expressed himself as follows: "Bless 'e, sir, the kids don't mind it. They never had the use o' fingers and toes, and so they never misses 'em." One of the girls with the 5th digit only on each hand is learning dressmaking as a pursuit. In Messrs Lewis and Embleton's family the gait appears to be normal†, but I should hardly say that this describes those members of the present family that I have seen. One who has long been acquainted with them writes:

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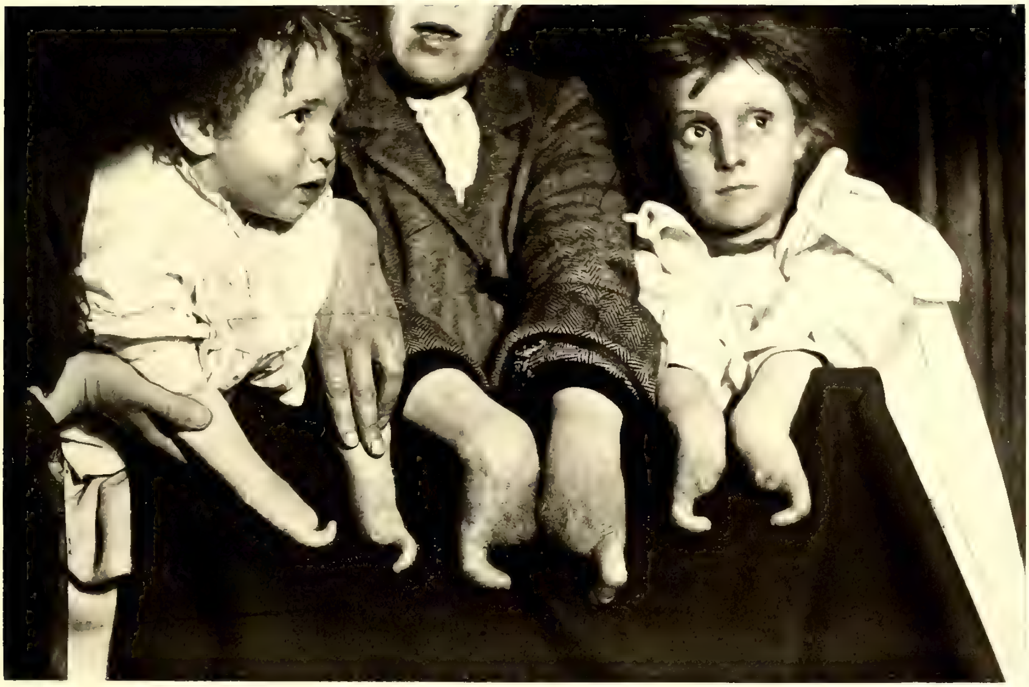
* E.g. the first digit of the foot existing in III. 21 and II. 2 disappears in the offspring of a marriage of III. 21 with a normal, as in IV. 21.

† *Biometrika*, Vol. VI. p. 28.



Hands of Mother (III. 21) and Daughters (IV. 21 and IV. 23)

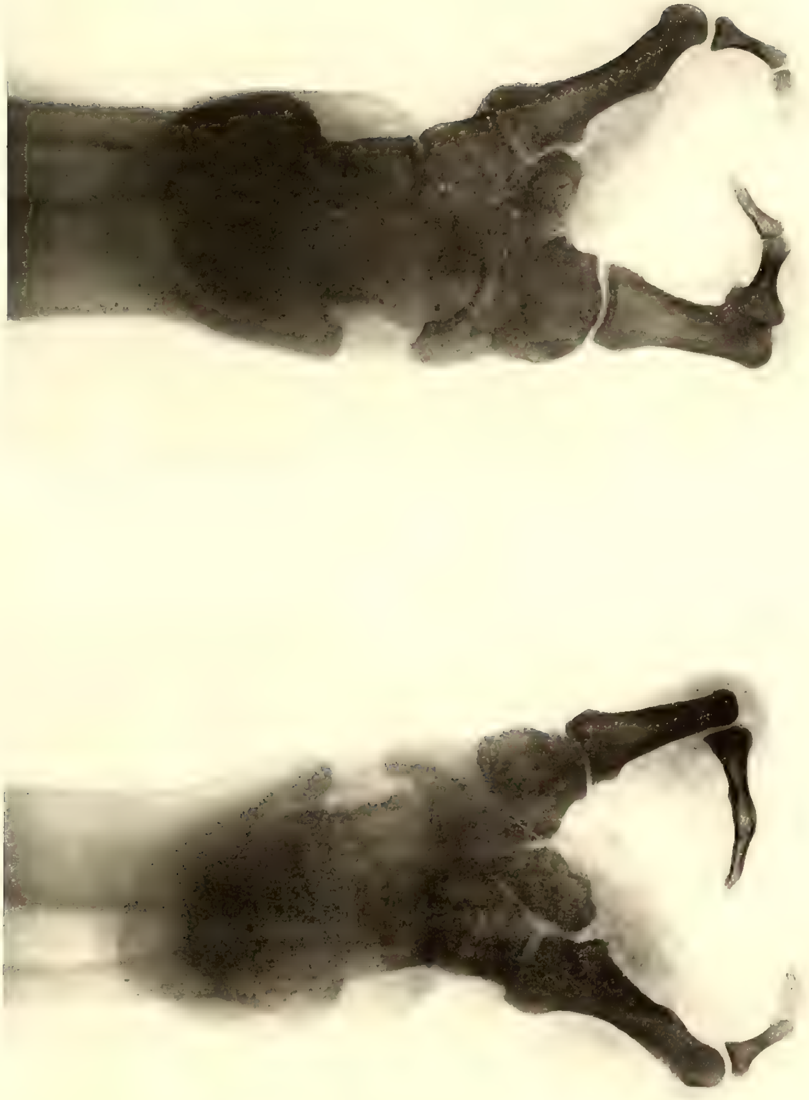


Fig. i

Fig. ii

Feet of Mother (III. 21). Front view

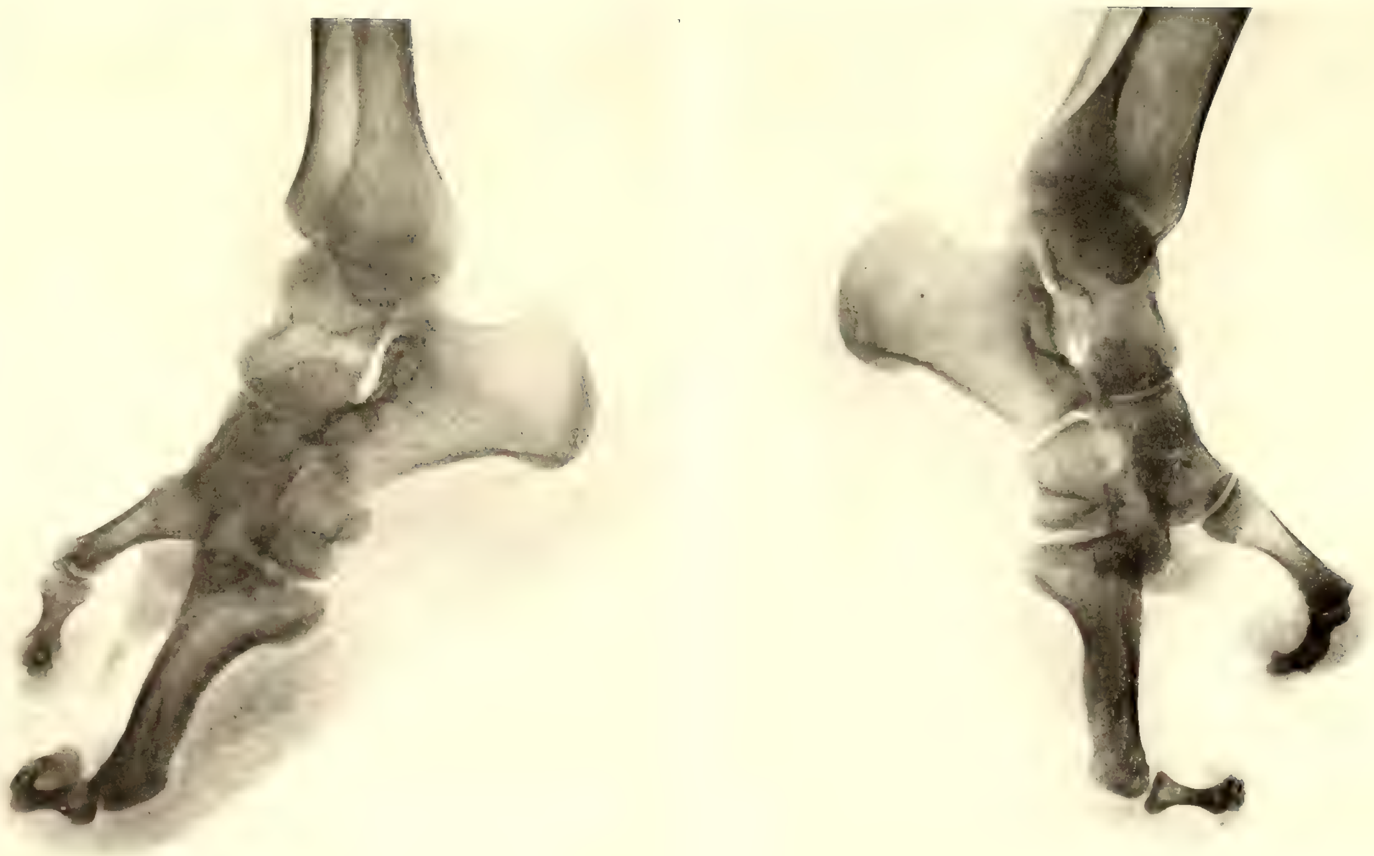


Fig. iii

Fig. iv

Feet of Mother (III. 21). Side view

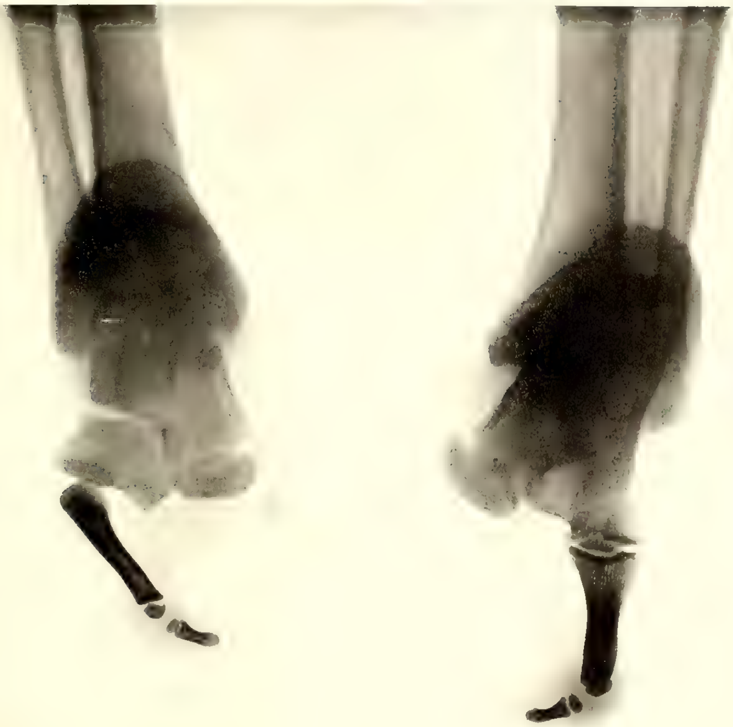


Fig. v

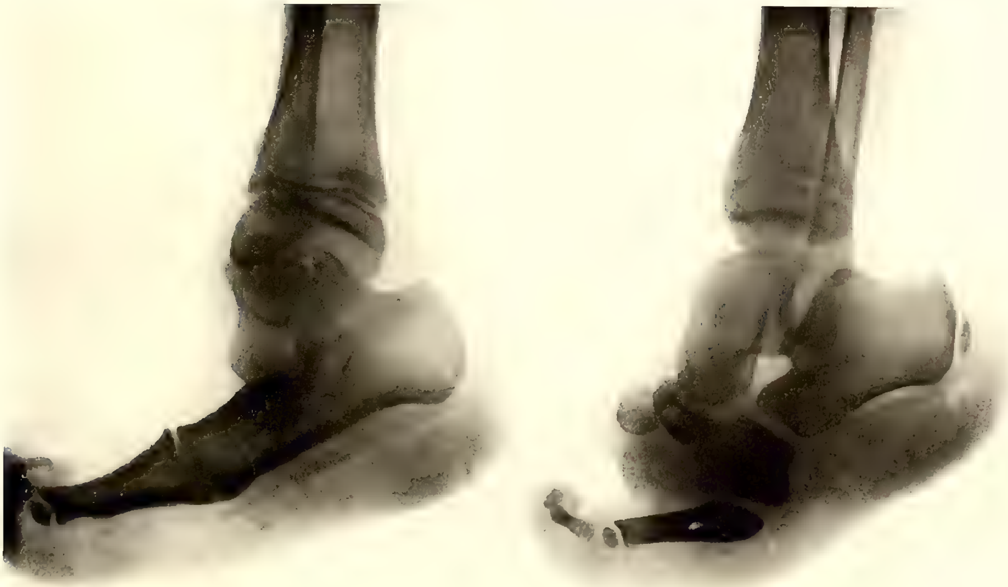


Fig. vi

Feet of elder Daughter (IV. 19). Front and side views

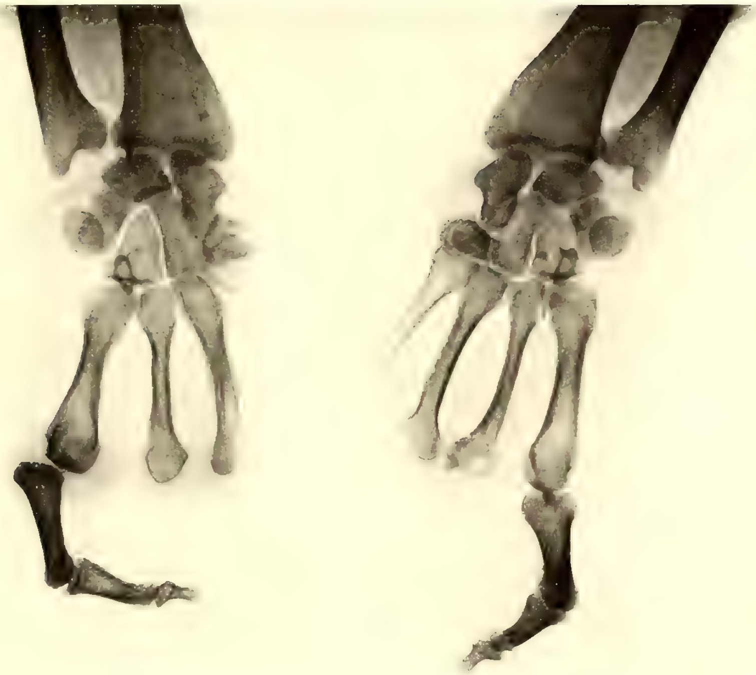


Fig. vii

Hands of Mother (III. 21)

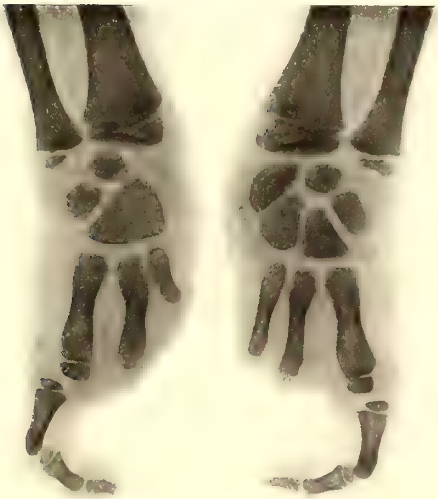


Fig. viii

Hands of elder Daughter (IV. 19)

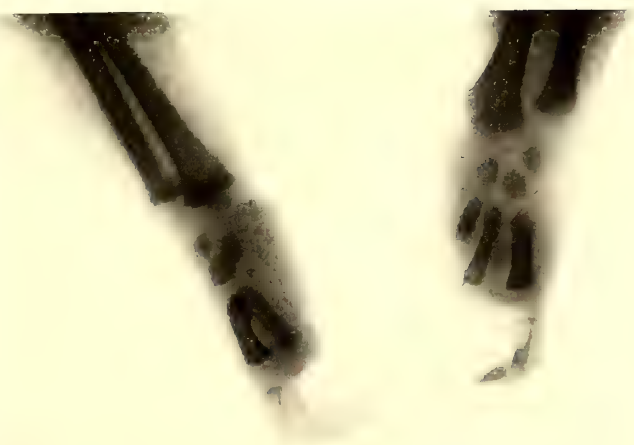


Fig. ix

Hands of younger Daughter (IV. 23)

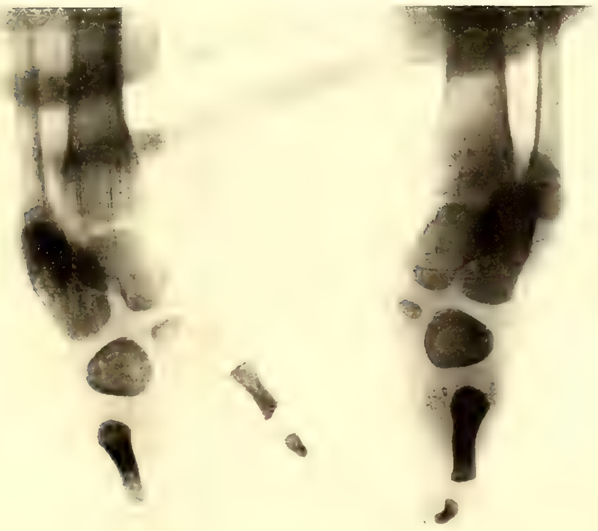


Fig. x

Feet of younger Daughter (IV. 23)

"Their feet lack the natural spring of the normal foot and their gait is therefore very ungainly, being assisted by a peculiar swing of the arms, much as a normal person would walk on heels alone. This is of course a great drawback, but not such as to incapacitate them from earning a living."

Turning to a further point we note that the deformed members seem to have no reduced fertility, nor do they appear to have difficulty in finding normal husbands or wives. On this account there is some concern at the perpetuation of the deformity in the district. Physically we may perhaps detect in some members signs of degeneracy, but they cannot be said as a rule to have weak constitutions. Intellectually the children take high rank in intelligence, or perhaps it would be better to say in "cuteness." Thus physically handicapped it would perhaps be unreasonable to expect in all members the highest social qualities, and assuming the stock to have been initially good, it may be doubted whether the deformity permits its members to select the physically and mentally fittest of normal mates. The stock is sufficiently extensive now to intermarry, and should it be ostracised might do so, a result which would have much scientific interest; but which might lead to the perpetuation of a split-foot race. Eugenically the problems associated with the family are not only scientifically difficult but practically serious; we live no longer in an age when the need for perfect hand and foot in the struggle for existence preserved the race from the perpetuation of a deformity. How is protection now to be maintained? In view of possible future legislation, it would seem for national purposes desirable that stocks of the present type should be kept under observation and careful records preserved of the history of all their branches. One of the most urgent social necessities is that every birth certificate should be associated with a medical certificate of the normality or abnormality of the child registered. A separate filing of the abnormal cases would not only keep the scientist in touch with important material, but provide the legislator with data whereby to appreciate the extent to which the suspension of natural selection is racially deleterious.

ON A MATHEMATICAL THEORY OF DETERMINANTAL INHERITANCE, FROM SUGGESTIONS AND NOTES OF THE LATE W. F. R. WELDON.

By KARL PEARSON.

(1) *Introductory.* In the memoir of Weldon's life published in the last volume of this Journal* occurs the following paragraph referring to the year 1905:

"In the summer the present writer was at East Ilsley, some seventeen miles from Oxford, and there was cycling out several times a week; the writer's chief work was on other than biometric lines and broken by other claims on his time, but there was steady joint work on the determinantal theory of inheritance as outlined by Weldon, and it is hoped that it is sufficiently advanced to be completed and published."

That hope is not wholly fulfilled. My mathematical draft of the theory was finally taken by Weldon from Ilsley to Oxford to be rewritten with proper biological terminology, and to have erroneous developments marked for reworking; this revision never appears to have been accomplished, and beyond my attempt at mathematical interpretation of Weldon's ideas, which I knew to be inapplicable at certain points, and his letters and a notebook full of numerical illustrations due to an earlier period of the same year, I have practically nothing to guide me in reconstructing Weldon's theory. The possibilities before me were threefold, to allow the matter to drop, to wait till I could find a cytologist with an interest in and a knowledge of the theory of chance at all comparable with Weldon's before going further, or lastly to publish what I could put together on my own responsibility. I have adopted the latter course, not because I am unconscious that I am likely to blunder, but because the material may at some time prove sufficiently suggestive to a reader with competent knowledge to cause him to take up the subject on broader and more effective lines, than I can pretend to do.

Accordingly for all that is suggestive or valuable in the present discussion Weldon is responsible. My contribution is solely the mathematical analysis, and even here directly, and by force of numerical illustration, he had gone a considerable way independently. Any defects in terminology and misstatements of cytological facts are mine alone.

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* Vol. v. p. 46.

In starting his investigations Weldon proceeded on very general lines, which it may be well to indicate. He was not inclined to accept the theory of unit characters, of allelomorphs and of pure gametes as capable of fully describing even the inheritance of the simplest characteristics. At the same time he recognised the importance of the segregation first pointed out by Mendel in the offspring of hybrids, though even here he was not prepared to make the segregating classes so distinct and so wanting in continuous variation, as some Mendelians have held them to be. He was convinced that in a sufficiently general theory of inheritance some place must be left for a normally arising percentage, however small, of variants, specially related to the distant ancestry. He was thus seeking for a mechanical explanation of latent characters, or in other aspects of reversions and even mutations.

In starting his work Weldon was perfectly catholic as to the possibility or not of paternal and maternal chromosomes retaining their individuality from the moment of fertilisation up to the reducing division of the germ cells. He did not consider this point as at present absolutely settled by the cytologists. While the retention of individuality immensely simplifies the analysis, this did not deter Weldon from investigating at great length the numerical results flowing from supposing an interchange of chromomeres at every mitosis.

The following rough notes of January 2, 1905, express the ideas then in his mind; it must be remembered that they were not written for publication, but as suggestions for his own work.

1. It is, I think, evident, from the facts of regeneration, that the theory of a nucleus as composed of specific organic determinants is hopeless. It is also evident from the behaviour of eggs, such as those of Ctenophora, that a special structure leading to determinate fate of special portions, may exist in the cell body.

2. The above facts do not invalidate conception of nuclear elements as a series of *stirps*, in Galton's sense, each containing something capable of exciting the development of any of the somatic characters, according to its position in the organism.

3. It seems necessary to regard a *stirp* as capable of exciting, not only somatic characters like those of its parents, but characters like those of its more remote ancestors under certain circumstances.

4. It is evident, from the facts of growth and regeneration, that the characters of any one stirp which become active in any one generation are determined by the position of that stirp with reference to the rest,—i.e. by a process of the same nature as Mendelian "dominance."

5. In an individual of pure race, the stirps will each contain the present and ancestral characters of that race. Assuming equality of numbers in germ cells which can fertilise each other (about which there is no real knowledge) the hybrid zygote should contain two sorts of stirps in equal numbers, each representing the race-characters of one parent. It seems possible on this assumption to develop a theory of nuclear division, which may give Mendel's results without eliminating ancestral influence,—i.e. without a theory of the "pure" gamete.

6. Such a theory would start by taking "chromomeres" as units. A chromosome of n chromomeres becomes entangled in the nuclear network: say there are in the zygote $2m$ chromosomes, there will be $2mn$ chromomeres in the resting nucleus. Before division these will be gathered into $2m$ groups for an ordinary mitosis, into m groups for a maturation mitosis,—the maturation division being afterwards heterotypic.

Weldon first proceeded on the basis of the non-individuality of the paternal and maternal chromosomes, and supposed a chance distribution of the chromomeres in ordinary mitosis. He investigated the problem with great wealth of numerical illustration and with a variety of hypotheses as to segregation. He concluded:

"It seems clear that such forms of segregation as I have assumed during nuclear division will not lead to a separation of zygotes into classes sufficiently sharp for Mendelian purposes, unless some persistence of effect from one mitosis to another be assumed."

He accordingly turned to the other extreme hypothesis, i.e. that from the moment of fertilisation up to the reducing division of the germ cells paternal and maternal chromosomes retain their individuality.

It is clear that this assumption disregards the reticulated stage of the chromosomes so far as its bearing on heredity is concerned. Weldon did not, however, reach the standpoint of the individual persistence and identity of the chromosomes during the reticulated state owing to a bias in favour of one or other theory. He recognised by extended numerical investigation of a number of cases that, if the chromomeres are the bearers of hereditary properties, interchange of chromomeres during ordinary mitosis was incompatible with any definite segregation in the offspring of hybrids. Throughout the theory hereinafter developed, the persistency of the individual chromosome up to the reducing division will be supposed to hold. The evidence in favour of this persistency is far from negligible, but it is hardly as complete as some Mendelians are inclined to believe. It is here accepted as a working hypothesis with the view of ascertaining whither it leads. That no hypothesis was found numerically workable and consistent with segregation phenomena, neither proves that such a hypothesis does not exist, nor demonstrates the universal truth of segregation. It merely indicates that in the present state of our knowledge we shall be most likely to reach suggestive and test results, if we follow up the idea of individuality in the chromosomes up to the reducing division.

(2) Let us suppose that each somatic cell consists of $2q$ chromosomes, effective with regard to any one inherited character*, and that each such chromosome contains p determinants on which the nature of this inherited character depends. If we start with a cell belonging to an individual of pure race we may suppose these p determinants alike, and the $2q$ chromosomes identical in character. We may speak of this first group of determinants as protogenic determinants and the corresponding chromosomes as protogenic chromosomes. Taking a cell belonging to an individual of a second pure race, it will also contain $2q$ chromosomes built up of p determinants. These may be termed the allogenic chromosomes and allogenic determinants. Suppose q protogenic chromosomes to be contained in a germ cell after the reducing division, and let them join with q allogenic chromosomes in a germ cell of the second race to form a zygote. Then whatever fusion of the

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* The whole number of chromosomes may be anything larger than $2q$.

nuclei may take place in the process of fertilisation, if we suppose the chromosomes to retain their individuality, there will be no interchange of chromomeres or their determinants between the allogenic and protogenic chromosomes in the zygote. Ordinary mitosis will now take place and somatic cells be indefinitely multiplied without interchange of determinants. Each hybrid cell will contain $2q$ chromosomes, q with p protogenic and q with p allogenic determinants.

The nature of the somatic characters of the hybrid will not be determinable in any way unless we have some theory as to whether the protogenic or allogenic determinants are dominant, or blend, or learn by experiment or observation that they give rise to certain characters which may differ from those of either pure race. We have a hybrid somatic cell in which there is a balance in number of the two types of determinants. As long as each ordinary mitosis divides equally the number of each kind of determinant in this heterogenic cell, it will not matter whether we suppose individual chromosomes to consist solely of determinants of one race, or each chromosome to have p protogenic and p allogenic determinants. The important point is that this equality of division should be maintained up to the reducing division. We shall now suppose that on the reducing division the protogenic and allogenic chromosomes fuse and interchange determinants, i.e. there is a random selection of p determinants out of the total $2p$, p protogenic and p allogenic determinants. This is equivalent to drawing p balls out of a bag containing p black (=protogenic) and p red (= allogenic) balls[*]. Or, the distribution of frequency of the several heterogenic chromosomes which contain $p, p-1, p-2, p-3, \ldots$ protogenic determinants is given by the successive terms of:

$$\frac{p\,!}{(2p)\,!}\left[1+p^2+\left\{\frac{p\,(p-1)}{1\,.\,2}\right\}^2+\left\{\frac{p\,(p-1)\,(p-2)}{1\,.\,2\,.\,3}\right\}^2+\ldots\right] \quad \ldots\ldots\text{(ii)}.$$

It is obvious that these terms are proportional to the squares of the binomial coefficients $(1+1)^p$.

If we take a second heterogenic cell and give it a reducing division, the frequency of the protogenic determinants in the resulting germ cells will be also given by (ii). Fertilisation of a heterogenic germ cell of q chromosomes by a second will lead to the somatic cell of the offspring of the 'hybrids.' This somatic cell contains $2q$ chromosomes each containing p determinants, and the frequency of the number of protogenic determinants in these chromosomes will be given by the expression

$$\left\{\frac{(p\,!)^2}{(2p)\,!}\left[1+p^2+\left\{\frac{p\,(p-1)}{1\,.\,2}\right\}^2+\left\{\frac{p\,(p-1)\,(p-2)}{1\,.\,2\,.\,3}\right\}^2+\ldots\right]\right\}^{2q} \ldots\text{(iii)};$$

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[*] It is well known that the chances of drawing $r, r-1, r-2, r-3 \ldots$ black balls out of a bag containing u black and v red balls are the successive terms of the series:

$$\frac{u\,!\ (u+v-r)\,!}{(u+v)\,!\ (u-r)\,!}\left\{1+r\frac{v}{u-r+1}+\frac{r\,(r-1)}{1\,.\,2}\,\frac{v\,(v-1)}{(u-r+1)\,(u-r+2)}\right.$$
$$\left.+\frac{r\,(r-1)\,(r-2)}{1\,.\,2\,.\,3}\,\frac{v\,(v-1)\,(v-2)}{(u-r+1)\,(u-r+2)\,(u-r+3)}+\ldots\ldots+\ldots\ldots\right\}\ldots\ldots\text{(i)}.$$

this is raised to the power of $2q$, since the two hybrid or heterogenic germ cells have the same constitution of chromosomes.

Now several possibilities arise at this stage of the development of the theory:

Suppose we have only a single chromosome in the germ cell, or two in the somatic cell, then $p = 1$ gives us the following condition of affairs: $\frac{1}{4}$ of the zygotes would consist of two chromosomes both with protogenic determinants, one-half of two chromosomes one with a protogenic and one with an allogenic determinant, and one-quarter with allogenic determinants alone. This is I take it pure Mendelism. The single determinant is the unit character and the protogenic and allogenic determinants are the allelomorphs. But a difficulty occurs in the fact that we must content ourselves with two chromosomes for most cases of inheritance. If we accept De Vries' view of an interchange of chromomeres bearing the determinants occurring at random between paternal and maternal chromosomes at the reducing division, then to reach pure Mendelism we must assert that only two chromosomes in the somatic cell, one in the germ cell, contain the inheritance factor for any character, and that this factor is built up of a single determinant. If we suppose for example that all the chromosomes, say $2q$ of them carry the determinant, then our distribution would be $(\frac{1}{2} + \frac{1}{2})^{2q}$, and it is clear that a homozygote would only result among the crossings of hybrids in a percentage far below the simple Mendelian 25. Thus De Vries' explanation appears to involve the narrow differentiation of the chromosomes, two only being concerned with any single character; or if more or all of them are to contain the determinant of any one character, then there must be some special mechanism to insure that all chromosomes at the random interchange of determinants before the reducing division interchange in precisely the same manner. We are not compelled to assume such a mechanism, which there is at present no cytological evidence in favour of, until it has been demonstrated that the experimental destruction, or observed absence of one or more chromosomes in a cell involves no loss of any series of characters. If a perfect zygote should develop from two germ cells, when half the nucleus of one has been removed, the problem of how De Vries' suggestion could lead to Mendelism would have to be further considered. Meanwhile let us proceed on the assumption, that there exist not a single Mendelian unit but p determinants for the character either in a single chromosome of the germ cell, or in q "tuned" chromosomes.

The distribution of protogenic determinants in the two, or the $2q$ "tuned," chromosomes of the somatic cells of the zygote will be given by the system of chances involved in the series

$$\frac{(p\,!)^4}{(2p\,!)^2}\left\{\pi^p + p^2\pi^{p-1}\alpha + \left(\frac{p\,(p-1)}{1\,.\,2}\right)^2\pi^{p-2}\alpha^2 + \frac{p\,(p-1)\,(p-2)}{1\,.\,2\,.\,3}\,\pi^{p-3}\alpha^3 + \ldots\right\}^2.$$

The symbols π and α here refer to protogenic and allogenic determinants; the chance of s protogenic and s' allogenic determinants occurring in the two chromosomes $(s + s' = 2p)$ or in the "tuned" q pairs of chromosomes, being given by picking out the numerical coefficient in the above expansion of $\pi^s\alpha^{s'}$.

I illustrate this on the first four cases.

Case 1. $p=1$.

$$\frac{1}{2\times 2}(\pi+\alpha)^2 = {\cdot}25\pi^2 + {\cdot}50\pi\alpha + {\cdot}25\alpha^2,$$

$$\begin{array}{rll}
\pi^2 & 25\ {}^\circ/_\circ & \text{Dominance of protogenic determinants,} \\
\alpha\pi & 50\ {}^\circ/_\circ & \text{Balanced heterogenic determinants,} \\
\alpha^2 & 25\ {}^\circ/_\circ & \text{Dominance of allogenic determinants.}
\end{array}$$

In this case it will be seen that the dominance of either determinant means a pure cell. The case is that of simple Mendelism and is the basis of a "pure gamete" theory.

Case 2. $p=2$.

$$\frac{2^4}{(4\,!)^2}\{\pi^2+4\pi\alpha+\alpha^2\}^2.$$

This gives

$$\begin{array}{rrll}
\pi^4 & 2{\cdot}78 & \multirow{2}{*}{$\left.\begin{array}{l}\\ \\\end{array}\right\} = 25\ {}^\circ/_\circ$} & \multirow{2}{*}{Dominance of protogenic determinant,} \\
\pi^3\alpha & 22{\cdot}22 & & \\
\pi^2\alpha^2 & 50{\cdot}00 & = 50\ {}^\circ/_\circ & \text{Balanced heterogenic determinants,} \\
\pi\alpha^3 & 22{\cdot}22 & \multirow{2}{*}{$\left.\begin{array}{l}\\ \\\end{array}\right\} = 25\ {}^\circ/_\circ$} & \multirow{2}{*}{Dominance of allogenic determinant.} \\
\alpha^4 & 2{\cdot}78 & &
\end{array}$$

This case is of peculiar interest; we get absolutely the Mendelian percentages, if the somatic character follows the preponderance of a given pure race determinant, using preponderance here in a simple numerical sense. Further, the protogenic 25 per cent. would apparently breed true to the somatic character of the pure protogenic race, if the somatic character of the balanced heterozygote were, as is occasionally asserted to be the case, indistinguishable from that of the protogenic race. The peculiar suggestiveness of this result lies in the exact Mendelian properties arising on a simple view of dominance apart from any hypothesis of the pure gamete. There exists a latent allogenic determinant in the heterogenic chromosome of a large percentage of the 25 per cent. with dominant protogenic character. This, if judicious cross-breeding were adopted, might be rendered manifest in some, if only a small number, of the grandchildren of the offspring of the hybrids.

Case 3. $p=3$.

$$\frac{(3\,!)^4}{(6\,!)^2}(\pi^3+9\pi^2\alpha+9\pi\alpha^2+\alpha^3)^2.$$

$$\begin{array}{rrll}
\pi^6 & 0{\cdot}25\ {}^\circ/_\circ & & \\
\pi^5\alpha & 4{\cdot}50\ {}^\circ/_\circ & \left.\begin{array}{l}\\ \\ \\\end{array}\right\} 29{\cdot}5\ {}^\circ/_\circ & \text{Dominance of protogenic determinant,} \\
\pi^4\alpha^2 & 24{\cdot}75\ {}^\circ/_\circ & & \\
\pi^3\alpha^3 & 41{\cdot}00\ {}^\circ/_\circ & 41\ {}^\circ/_\circ & \text{Balanced heterogenic determinants,} \\
\pi^2\alpha^4 & 24{\cdot}75\ {}^\circ/_\circ & & \\
\pi\alpha^5 & 4{\cdot}50\ {}^\circ/_\circ & \left.\begin{array}{l}\\ \\ \\\end{array}\right\} 29{\cdot}5\ {}^\circ/_\circ & \text{Dominance of allogenic determinant.} \\
\alpha^6 & 0{\cdot}25\ {}^\circ/_\circ & &
\end{array}$$

Here, if the balanced heterogenic group be classed with the protogenic group, we should have the ratio 70·5 to 29·5, and most readers will remember worse experimental Mendelian quarters than this. The illustration shows that it is quite possible to get numbers approaching the Mendelian when there really exists a considerable variety in the determinantal constitution of the cells in which the protogenic race is dominant.

Case 4. $p=4$.

$$\frac{(4\,!)^4}{(8\,!)^2}\{\pi^4+16\pi^3\alpha+36\pi^2\alpha^2+16\pi\alpha^3+\alpha^4\}^2.$$

π^8	0·020 °/₀	$\pi^3\alpha^5$	24·163 °/₀
$\pi^7\alpha$	0·653 °/₀	$\pi^2\alpha^6$	6·694 °/₀
$\pi^6\alpha^2$	6·694 °/₀	$\pi\alpha^7$	0·653 °/₀
$\pi^5\alpha^3$	24·163 °/₀	α^8	0·020 °/₀
$\pi^4\alpha^4$	36·939 °/₀		

Thus we see that there would be 31·5 °/₀ with dominance of protogenic determinant, 37 °/₀ with balanced heterogenic determinants and 31·5 °/₀ with dominance of allogenic determinant. The distribution is diverging considerably from the simple Mendelian quarter and approaching much more nearly a normal distribution (or binomial distribution) in the protogenic determinants.

No special stress is laid on the above examples, I have only taken them to indicate, how simple Mendelism passes when we increase the number of determinants concerned from a pure gamete theory to one in which we have dominance with closely Mendelian proportions, but diversity of gametic constitution in the dominant quarter, which might not cease to be latent for two or more generations. Again, on still further increasing the number of determinants, we pass to what is clearly a close approximation to the normal curve of distribution. It seems desirable, therefore, to investigate further the general theory of p determinants each occurring in two or in $2q$ "tuned" chromosomes.

(3) Returning to the fundamental formula (ii), which gives the distribution of protogenic determinants in the chromosomes of the germ cell, we note the complexity of the analysis required to deal further with it in its present shape. But we see that it is formed by the squares of the terms of a symmetrical binomial. Now for p even moderately large this binomial is extremely close to a normal curve, and accordingly the squares of the ordinates of this curve will represent extremely closely our series. But the squares of the ordinates of a normal curve are themselves ordinates of a normal curve. Thus the normal curve* which fits closely $(\frac{1}{2}+\frac{1}{2})^p$ is $y=\frac{1}{\sqrt{2\pi}\,\sigma}e^{-\frac{1}{2}x^2/\sigma^2}$, where $\sigma=\sqrt{\frac{1}{4}(p+1)\,c^2}$, and c is the unit of plotting. Very frequently $\sqrt{\frac{1}{4}p}\,c$ is taken for σ, and p being

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[*] *Phil. Trans.* Vol. 186, A, p. 355.

large, there is no sensible difference. Since $y \times c$ gives approximately the ordinates of $\frac{1}{2^p}(1+1)^p$, we may expect

$$\frac{2^{2p}(p\,!)^2}{(2p)\,!}\,y^2c \text{ to give the terms of (ii).}$$

Or, supposing p moderately large and using Stirling's Theorem, we may anticipate that the terms of (ii) will be given fairly well by

$$Y = \frac{1}{\sqrt{2\pi}}\,\frac{1}{\sqrt{\frac{1}{8}pc^2}}\,e^{-\frac{x^2}{2\frac{1}{8}pc^2}} \quad\text{..............................(iv).}$$

This is a normal curve of standard deviation $\sqrt{\frac{1}{8}p}\,c$, and accordingly it must again be closely given by the binomial $(\frac{1}{2}+\frac{1}{2})^{\frac{1}{2}p}$. I find that the *areas* of (iv) give (ii) closely, but that if we work with ordinates we get a better result from $\sqrt{\frac{1}{8}(p+\frac{1}{2})}\,.\,c$ as the standard deviation of the normal curve, i.e. neither using p nor $p+1$, but the mean of these values. The following table illustrates the closeness of approximation for $p=12$:

		Normal curve	
Accurate values from (ii)	$(\frac{1}{2}+\frac{1}{2})^{\frac{1}{2}p}$	Areas ($\sigma=\sqrt{\frac{1}{8}p}=1{\cdot}22475$)	Ordinates [$\sigma=\sqrt{\frac{1}{8}(p+\frac{1}{2})}=1{\cdot}25$]
·0000	·0000	·0000	·0000
·0001	·0000	·0001	·0001
·0016	·0000	·0020	·0019
·0179	·0156	·0185	·0179
·0906	·0937	·0897	·0887
·2320	·2344	·2306	·2318
·3156	·3125	·3181	·3191
·2320	·2344	·2306	·2318
·0906	·0937	·0897	·0887
·0179	·0156	·0185	·0179
·0016	·0000	·0020	·0019
·0001	·0000	·0001	·0001
·0000	·0000	·0000	·0000

It is clear that for all practical purposes the normal distribution, and even the simple binomial, may replace the expression in (ii) for the distribution of determinants in the heterogenic chromosome when p is as large as 12. The errors of the actually available samples, 500 to 1000 at most of each generation, will be well within the errors of random sampling. Even if $p=4$, the agreement between (ii) and $(\frac{1}{2}+\frac{1}{2})^2$ is not wildly out:

·0143	·0000
·2286	·2500
·5143	·5000
·2286	·2500
·0143	·0000

In fact it would often be extremely difficult to distinguish between (ii) for $p=4$ and a true $\frac{1}{4}$, $\frac{1}{2}$ and $\frac{1}{4}$ system of frequency. For example, in any breeding experiment yet made we may well doubt whether it has been on a scale sufficient to distinguish between 51 and 24 per cent. as compared between 50 and 25 per cent. We are therefore justified in replacing (ii) by a normal curve for practical purposes. If we calculate areas we may take its standard deviation $\sqrt{\frac{1}{8}p}$; if we calculate ordinates we shall get a somewhat better result from $\sqrt{\frac{1}{8}(p+\frac{1}{2})}$, but for p as large as 12, the results will agree within the errors of random sampling for practical series.

We have now found a fairly simple analytical form for the distribution of determinants in the chromosome of a gametic cell of the hybrid. The probability that the chromosome of the gametic cell of the hybrid will have a number of determinants of protogenic character lying between $\frac{1}{2}p+x/c$ and $\frac{1}{2}p+(x+\delta x)/c$ is

$$\frac{1}{\sqrt{2\pi}}\frac{1}{\sqrt{\frac{1}{8}pc}}e^{-\frac{1}{2}x^2/\sqrt{\frac{1}{8}p}\,c^2}\,\delta x \;\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\text{(iv) } \textit{bis}.$$

The close resemblance of this result to $(\frac{1}{2}+\frac{1}{2})^{\frac{1}{2}p}$ shows that the variability of the chromosomes in the number of protogenic determinants is practically confined to the range of $\frac{1}{4}p$ to $\frac{3}{4}p$. More accurately, only two individuals per thousand would have more than $\frac{1}{2}p+\sqrt{p}$ protogenic determinants.

Now the gametic cells of both hybrid parents will have a distribution of this character, and supposing random mating among the hybrids, the frequency of protogenic determinants in the zygotes will be given by a normal curve of standard deviation Σ where

$$\Sigma^2=\tfrac{1}{8}pc+\tfrac{1}{8}pc, \text{ or } \Sigma=\sqrt{\tfrac{1}{4}p}\,.\,c.$$

Thus the frequency with which $p+s$ protogenic and $p-s$ allogenic determinants occur in the somatic cell chromosomes of the offspring of the hybrids is given by the normal curve

$$y=\frac{1}{\sqrt{2\pi}}\frac{1}{\sqrt{\frac{1}{4}pc^2}}e^{-\frac{1}{2}x^2/(\frac{1}{4}pc^2)} \;\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\text{(v)},$$

where $s=x/c$.

(4) We have now to determine the constitution of the gametic cells of the offspring of the hybrids or to take away by the reducing division p determinants at random from $p+s$ protogenic and $p-s$ allogenic determinants. The result is reached at once by substituting in (i) of p. 83 the values $u=p+s$, $v=p-s$, $r=p$. But the complexity of the result would be great (for general theoretical purposes apart from special numerical illustration) if we did not use some close-fitting continuous curve for the series. Such a curve is provided for in my memoir "On Skew Variation in Homogeneous Material*." In the notation of that memoir we find

$$\beta_1=\frac{c^2\{(1+p)^2-s^2\}}{8(p+1)}, \quad \beta_2=0, \quad \beta_3=\frac{1}{2(p+1)} \;\ldots\ldots\ldots\ldots\text{(vi)},$$

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* *Phil. Trans.* Vol. 186, A, p. 361.

and hence the differential equation to the curve

$$\frac{1}{y}\frac{dy}{dx}=\frac{-x}{\beta_1+\beta_2x+\beta_3x^2}$$

becomes simply

$$\frac{1}{y}\frac{dy}{dx}=\frac{-2x(p+1)}{\frac{1}{4}c^2\{(1+p)^2-s^2\}+x^2} \quad\text{..........................(vii).}$$

Whence, integrating, we find

$$y=y_0\frac{1}{[\frac{1}{4}c^2\{(1+p)^2-s^2\}+x^2]^{p+1}} \quad\text{.....................(viii).}$$

Here x is measured from the modal value which is clearly the same as the mean, and corresponds to a length $\frac{1}{2}(p+s)c$, or to the number $\frac{1}{2}(p+s)$ of protogenic determinants. Further, y_0 will be a function of s which remains to be determined.

Let n_s be the total frequency corresponding to somatic cells of the offspring of the hybrids, i.e. to the cells before the reducing division. We must have

$$n_s=\int_{-\infty}^{+\infty}y\,\delta x=y_0\int_{-\infty}^{+\infty}\frac{dx}{(\lambda_s^2+x^2)^{p+1}},$$

where $\lambda_s^2=\frac{1}{4}c^2\{(1+p)^2-s^2\}$. Let $x=\lambda_s\tan\theta$, then

$$n_s=y_0\int_{-\frac{1}{2}\pi}^{+\frac{1}{2}\pi}\cos^{2p}\theta\,d\theta/\lambda_s^{2p+1}.$$

Or

$$y_0=n_s\lambda_s^{2p+1}/i_{2p},$$

where $i_{2p}=\int_0^{\pi}\sin^{2p}\phi\,d\phi$ is a well-known integral.

Thus (viii) becomes

$$y=\frac{n_s\lambda_s^{2p+1}/i_{2p}}{(\lambda_s^2+x^2)^{p+1}} \quad\text{..................................(ix).}$$

But x is measured from $\frac{1}{2}(p+s)c$ the mean value of protogenic determinants in the gametic cells of the offspring of the hybrids. Let us write $x=-\frac{1}{2}sc+\xi$, then

$$y=\frac{n_s\lambda_s^{2p+1}/i_{2p}}{\{\frac{1}{4}c^2(1+p^2)+\xi^2-sc\xi\}^{p+1}} \quad\text{.........................(x).}$$

To find n_s, we must note that it is defined by the strip $y'\delta x'$ of a normal curve

$$y'=\frac{1}{\sqrt{2\pi}}\frac{1}{\sqrt{\frac{1}{4}pc^2}}e^{-\frac{1}{2}x'^2/(\frac{1}{4}pc^2)},$$

where $x'/c=s$, for this is the distribution for the somatic cells of the offspring of the hybrids.

Thus the frequency for the germ cells of the offspring of the hybrids of chromosomes with $\frac{1}{2}p+\xi/c$ protogenic determinants arising from offspring of hybrids with somatic cells with chromosomes with $p+x'/c$ protogenic determinants is given by the surface

$$z=z_0\frac{\{\frac{1}{4}c^2(1+p)^2-\frac{1}{4}x'^2\}^{p+\frac{1}{2}}}{\{\frac{1}{4}c^2(1+p)^2+\xi^2-x'\xi\}^{p+1}}e^{-\frac{1}{2}x'^2/(\frac{1}{4}pc^2)} \quad\text{...............(xi),}$$

where z_0 is a function of p, but not of x'. This is nothing else than the correlation surface between the number of protogenic determinants in somatic cell chromosomes of the offspring of the hybrids and the number of protogenic determinants in the germ cell chromosomes of the same individuals.

(xi) is again somewhat complex, but it will suffice to reduce it for most practical purposes to a normal correlation surface. Thus

$$\{\tfrac{1}{4}c^2(1+p)^2+\beta^2\}^{p+1}=\{\tfrac{1}{4}c^2(1+p)^2\}^{p+1}\left\{\left[1+\frac{\beta^2}{\tfrac{1}{4}c^2(1+p)^2}\right]^{(1+p)^2}\right\}^{1/(1+p)}$$

$$=\{\tfrac{1}{4}c^2(1+p)^2\}^{p+1}e^{\beta^2/\{\frac{1}{4}c^2(1+p)\}}\text{ approximately.}$$

Similarly we have

$$\{\tfrac{1}{4}c^2(1+p)^2-\tfrac{1}{4}\gamma^2\}^{p+\frac{1}{2}}=\{\tfrac{1}{4}c^2(1+p)^2\}^{p+\frac{1}{2}}\left\{\left[1-\frac{\gamma^2}{c^2(1+p)^2}\right]^{(1+p)^2}\right\}^{1/m}$$

$$=\{\tfrac{1}{4}c^2(1+p)^2\}^{p+\frac{1}{2}}e^{-\gamma^2/(c^2m)},$$

where $m=(1+p)^2/(\frac{1}{2}+p)$.

Thus the correlation surface, if z_0' be a new function of p only, is given by

$$z=z_0'e^{-\frac{x'^2}{c^2m}-\frac{\xi^2-x'\xi}{\frac{1}{4}c^2(p+1)}-\frac{1}{2}\frac{x'^2}{\frac{1}{4}pc^2}}\quad\text{.................................(xii).}$$

Writing this in the form

$$z=z_0'e^{-\frac{1}{2}\frac{1}{1-R^2{}_{s_2g_2}}\{x'^2/\Sigma^2{}_{s_2}-2R_{s_2g_2}x'\xi/\Sigma_{s_2}\Sigma_{g_2}+\xi^2/\Sigma^2{}_{g_2}\}},$$

we easily find

$$\left.\begin{array}{l}
R_{s_2g_2}=\dfrac{1}{\sqrt{3}}\sqrt{\dfrac{p^2+p}{p^2+\frac{3}{2}p+\frac{2}{3}}}=\left\{\begin{array}{l}\text{Correlation between somatic and gametic}\\ \quad\text{cells of offspring of hybrids.}\end{array}\right.\\[2ex]
\Sigma_{g_2}=\dfrac{\sqrt{3}}{4}\sqrt{p}\,c\sqrt{\dfrac{p+1}{p}\,\dfrac{p^2+\frac{3}{2}p+\frac{2}{3}}{p^2+\frac{7}{4}p+1}}=\left\{\begin{array}{l}\text{Standard deviation of somatic}\\ \quad\text{cells of offspring of hybrid.}\end{array}\right.\\[2ex]
\Sigma_{s_2}=\tfrac{1}{2}\sqrt{p}\,c\,\dfrac{p+1}{\sqrt{p^2+\frac{7}{4}p+1}}=\left\{\begin{array}{l}\text{Standard deviation of gametic cells of}\\ \quad\text{offspring of hybrid.}\end{array}\right.
\end{array}\right\}\ldots\text{(xiii).}$$

Thus we find

p	$R_{s_2g_2}$	$\Sigma_{g_2}\Big/\frac{\sqrt{3}}{4}\sqrt{p}c$	$\Sigma_{s_2}/\frac{1}{2}\sqrt{p}c$
2	·5108	1·1632	1·0290
4	·5423	1·0865	1·0206
6	·5537	1·0590	1·0157
∞	·5773	1·0000	1·0000

It will be noted that as p increases the correlation rapidly approaches the value ·5773 and the variability of the gametic and somatic chromosomes the values $\frac{\sqrt{3}}{4}\sqrt{p}c$ and $\frac{1}{2}\sqrt{p}c$. Thus we see that, according to the theory here developed, the chromosomes of the somatic cells are absolutely more variable in the ratio of 1 to ·866 than those of the gametic cells. But, if we deal with their relative variabilities as measured by their coefficients of variation, the gametic cells are more variable in the ratio of 1·73 to 1. The regression of the gametic chromosomes on the somatic chromosomes gives us the value $\frac{1}{\sqrt{3}}\frac{\sqrt{3}}{4}\sqrt{p}\,c/(\frac{1}{2}\sqrt{p}\,c)=\frac{1}{2}$, or ·5 is the value this regression takes even when p is a small number.

Thus, while there is no variation in the somatic cells either of the pure races or of the hybrids, and accordingly while it is impossible to find a correlation between somatic and gametic cells for these generations, its value being indeterminate, we see that as soon as we reach the offspring of the hybrids, a sensible and definite correlation exists, and this correlation has a value which may be suggestive for other forms of enquiry. The present writer is fully aware that a variety of other mathematical theories of the broad facts of cytology may be developed, and as our knowledge increases more ample theories, consonant possibly with a wider range of facts, will probably be invented. But he believes that the present theory is the first to show that there will be a definite correlation between the determinantal structure of the chromosomes in the somatic and in the gametic cells, and that its value will not improbably be found to be about ·5. Looked at from this standpoint the somatic cell precedes the germ cell of the individual, and the somatic cell might, under the proper stimulus, give rise to a germ cell. These germ cells are not of one type; they are variable, but correlated with the originating somatic cell. It is difficult, if we look at matters for the time being from this aspect, to find any basis for a "continuity of the germ plasm." Every reducing division may produce a new germ cell, and the whole group of germ cells is relatively more variable than the somatic cells from which they arise. The link between the two is one of correlation and not causation, a result produced by the random partition in the reducing division.

(5) I now turn to the somatic cells of the grandchildren of the hybrids, i.e. the children H_2 of the offspring H_1 of the hybrids H.

Let $p+\frac{x_1}{c}$ be the number of protogenic determinants in the chromosomes of the somatic cell of the first parental H_1, and $\frac{1}{2}p+\xi_1/c$ be the number of protogenic determinants in the chromosome of the gametic cell of this parent. Let $p+x_2/c$, and $\frac{1}{2}p+\xi_2/c$ be the corresponding quantities for the second parent and let us suppose the matings among the H_1 absolutely random. Then the number of protogenic determinants in the two chromosomes of the somatic cell of the offspring H_2 is $p+(\xi_1+\xi_2)/c=p+s'''$, say. We require to find the correlation surface between s''' and s' and s'' (or x_1/c and x_2/c) or the deviations from the mean p of the protogenic determinants in the offspring H_2 and the two parents H_1. Let us write $\eta=\xi_1+\xi_2$, and since when p is only moderately large we have seen that $p+1$ and $m=(p+1)^2/(p+\frac{1}{2})$ may be practically replaced by p, we shall write for (xii)

$$z=z_0'e^{-\frac{1}{2}\left\{\frac{\xi^2}{\frac{1}{8}c^2p}-\frac{2x'\xi}{\frac{1}{4}c^2p}+\frac{x'^2}{\frac{1}{6}c^2p}\right\}},$$

Accordingly the chance from parental somatic cells lying between x_1 and $x_1+\delta x_1$ and x_2 and $x_2+\delta x_2$ of getting gametic cells respectively between ξ_1 and $\xi_1+\delta\xi_1$ and ξ_2 and $\xi_2+\delta\xi_2$ is measured by

$$Z_0'e^{-\frac{1}{2}\frac{1}{c^2p}\{8(\xi_1^2+\xi_2^2)-8(x_1\xi_1+x_2\xi_2)+6(x_1^2+x_2^2)\}}\,dx_1dx_2d\xi_1d\xi_2,$$

where Z_0' is a constant depending on p and c only. Write for ξ_1, $\eta-\xi_2$, and the chance becomes

$$Z_0'e^{-\frac{1}{2}\frac{1}{c^2p}\{8(2\xi_2^2-2\eta\xi_2+\eta^2)-8(\eta x_1+(x_2-x_1)\xi_2)+6(x_1^2+x_2^2)\}}\,dx_1dx_2d\eta d\xi_2.$$

Now integrate this expression throughout the range of values of ξ_2 and we shall have the triple correlation surface connecting x_1, x_2 and η. In order to do this we must make the result a perfect square in ξ_2. We thus find

$$Z_0'e^{-\frac{1}{2c^2p}\{16(\xi_2-\frac{1}{2}[\eta+\frac{1}{2}(x_2-x_1)])^2+4\eta^2+5(x_1^2+x_2^2)-4\eta(x_1+x_2)+2x_1x_2\}}\,d\xi_2d\eta dx_1dx_2.$$

Integrating throughout the range of ξ_2, we only modify the constant Z_0' without changing the terms in η, x_1, or x_2. Thus the frequency surface is finally of the form:

$$z=z_0e^{-\frac{1}{2}\left\{\frac{\eta^2}{\frac{1}{4}c^2p}+\frac{x_1^2}{\frac{1}{5}c^2p}+\frac{x_2^2}{\frac{1}{5}c^2p}-\frac{2\eta x_1}{\frac{1}{2}c^2p}-\frac{2\eta x_2}{\frac{1}{2}c^2p}+\frac{2x_1x_2}{c^2p}\right\}}\quad\text{............(xiv).}$$

Let r be the correlation between chromosome in the parents' and in the offspring's somatic cells, then:

The correlation of η with either x_1 or $x_2=r$, and the correlation of x_1 and $x_2=0$.

Let σ_1 and σ_2 be the equal standard deviations of x_1 and x_2; σ_3 of η.

Then the bracket term ought to be equal to

$$\frac{1}{1-2r^2}\left\{\frac{\eta^2}{\sigma_3^2}+\frac{x_1^2(1-r^2)}{\sigma_1^2}+\frac{x_2^2(1-r^2)}{\sigma_1^2}-\frac{2\eta x_1r}{\sigma_3\sigma_1}-\frac{2\eta x_2r}{\sigma_3\sigma_1}+\frac{2r^2x_1x_2}{\sigma_1^2}\right\}.$$

Hence we deduce:

$$\frac{1}{\sigma_3^2}\frac{1}{1-2r^2}=\frac{4}{c^2p},\quad \frac{1}{\sigma_1^2}\frac{1-r^2}{1-2r^2}=\frac{5}{c^2p},\quad \frac{1}{\sigma_3\sigma_1}\frac{r}{1-2r^2}=\frac{2}{c^2p},\quad \frac{r^2}{\sigma_1^2}\frac{1}{1-2r^2}=\frac{1}{c^2p^2}.$$

The second and fourth equations give us $r^2=1/6$, agreeing with the value obtained from the first, second and third. The first and second then give

$$\sigma_3^2=\tfrac{3}{8}c^2p \text{ and } \sigma_1^2=\tfrac{1}{4}c^2p.$$

Thus finally we have:

Variability of the somatic cells in H_1 or in the offspring of hybrids $=\frac{1}{2}c\sqrt{p}$.

Variability of the somatic cells in H_2 or offspring of $H_1=\sqrt{\frac{3}{2}}\,\frac{1}{2}c\sqrt{p}$.

Correlation of the somatic cells in parents H_1 and offspring $H_2=\frac{1}{\sqrt{6}}=\cdot 4082$.

Regression of the filial on the parental somatic cells $=\cdot 5000$.

These results seem to be of not a little interest. They indicate that if two pure races be crossed, the variability in protogenic determinants of the chromosomes of the somatic cells will be still increasing to the third generation, i.e. it is 1·225 times as great in the H_2 generation as in the H_1 generation. The correlation, however, is rapidly assuming a value very close to those which have been determined biometrically for large populations mating at random, and the regression has already reached that value ·5*.

It is noteworthy that the regression of the gametic cell of an individual on the somatic cell of that individual is identical in value with the regression of the somatic cell of the offspring on the somatic cell of the individual.

(6) I have not thought it worth while at present to proceed with further reducing divisions, although the results would not be without interest as determining the rate at which a stable population was established after crossing two "pure races," owing to the cessation of change in the variability of successive generations, and to the corresponding equalisation of correlation and regression. The present investigation suffices to show that we fairly rapidly approach the biometrically observed condition of things, even if we start with two pure races, and this result will be shown on another occasion to be experimentally verified. It may, of course, be said that the hypothesis which makes the inherited character depend on p unit determinants in the paternal and maternal chromosomes, separated into two moieties at random in the reducing division, is not the only conceivable one. This is fully admitted, but by working it out as a first and not unreasonable hypothesis, we have reached a number of suggestive points. We see that Mendelian dominance and the Mendelian quarter may arise in cases where there is no pure gamete, and that the discovery of a latent character may need several generations of breeding. Further we see a continuous transition from simple Mendelism, through various phases of pseudo-Mendelism to distributions closely following the normal curve. We notice also that if we increase the number of determinants on which a character depends, we very soon, even if we start with two pure races, reach by hybridisation and crossing of the hybrids a population closely following the correlation found biometrically for large groups mating at random. If the hypothesis here dealt with were correct, it would follow that the Mendelians were merely working at one end of the scale, the biometricians somewhat further down. At present interesting problems which suggest themselves are: the possibility of in any way correlating the somatic and the resulting gametic cells; the existence or not of ratios actually or nearly Mendelian, but where the apparent homozygotes do not breed true; lastly, the investigation of whether or not the values of parental correlation hold closely when we have bred for only a couple of generations from the hybrids of two pure stocks. With regard to this last problem, we may hope shortly for light; Mendelian literature for the careful reader may provide answers, perhaps, to the second.

At present it does not seem needful to defend the assumptions upon which the present theory is based. It suffices that it is sufficiently wide as it stands to cover the Mendelian and the biometric views. It has been expounded here on account of its suggestiveness. What there is of good in it is Weldon's; where it may blunder is where I have failed to correctly interpret by word or symbol his ideas.

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* The fact that there is in this case a difference between the correlation and regression depends upon the variability of the somatic cells of the two generations not yet being equal.

MISCELLANEA.

I. Some Notes on Interpolation in n-dimension Space.

By W. PALIN ELDERTON.

1. *Introductory.* The main idea of this paper is summed up in the principle, or the extension of the principle, that in certain cases the use of linear second differences will give a better result than the use of two-variable first differences, e.g. three points in the table chosen on a straight line may give a more accurate interpolation than the four "nearest" points. The usual formulae of interpolation assume that we require to find from tabulated values of u_x a value of the function corresponding to a certain value of x not among the tabulated cases. In some circumstances we have to deal with a function of two variables, and it was recently shown by Mr John Spencer* that in certain circumstances the simple one-variable interpolation formulae could be used. This saves a great deal of work in practice, and in the examples dealt with it was found to give accurate results. The object of the present paper is to supply a general method and to show that it is not necessary to limit the number of variables to two. Before proceeding to the subject itself it will be well to outline the alternative methods available. The most usual practice in two-variable interpolation is to interpolate between four values; thus if u_{rs} is required and u_{00}, u_{01}, u_{10} and u_{11} are given, then u_{r0} is found from u_{00} and u_{10}, and u_{r1} from u_{01} and u_{11}, and then u_{rs} from u_{r0} and u_{r1}. Graphically these processes might be represented by the following diagram, in which the dots show the positions of the given values, the crosses the positions of the interpolated values, and the lines connecting the points indicate the values used in each interpolation. Of course to give the values in a figure we should have to erect perpendiculars to the surface of the paper.

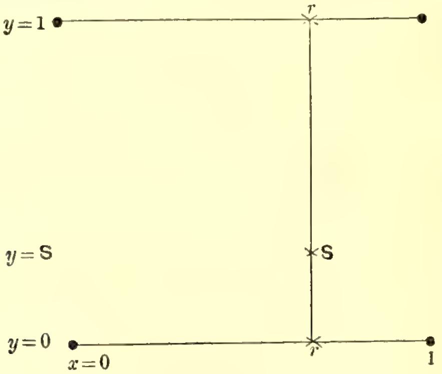

FIG. 1.

The general solution in terms of differences is obtained by expanding the right-hand side of

$$u_{rs} = (1+\Delta_x)^r (1+\Delta_y)^s u_{00},$$

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* John Spencer, "Some practical hints on two-variable interpolation," *Journal of the Institute of Actuaries*, Vol. XL. pp. 293 *et seq.*

but it is, I think, better to use coefficients* instead of differences, just as one does when employing Lagrange's formula in the ordinary one-variable interpolation, and with the help of auxiliary tables such as those of Mr Herbert H. Edwards† very accurate results can be easily obtained. If however the intervals by which the given table of the function proceeds are different from those adopted by Mr Edwards, a large amount of arithmetical work is necessary. It is however worth while to recapitulate the method and increase the number of the independent variables from two to n. Assuming that we require to find $u_{rst\ldots(n)}$; then by Lagrange's interpolation formula we have

$$u_{rst\ldots} = r_0 u_{0st\ldots} + r_1 u_{1st\ldots} + r_2 u_{2st\ldots} \text{ etc.},$$

where r_0, $r_1 \ldots$ are numerical coefficients depending on the number of terms and the value of r. And similarly

$$u_{srt\ldots} = s_0 u_{0rt\ldots} + s_1 u_{1rt\ldots} + s_2 u_{2rt\ldots},$$

$$u_{trs\ldots} = t_0 u_{0rs\ldots} + t_1 u_{0rs\ldots} + t_2 u_{0rs\ldots},$$

and so on; hence

$$\begin{aligned} u_{rst\ldots} &= r_0 s_0 t_0 \ldots u_{000\ldots} + r_0 s_0 t_1 \ldots u_{001\ldots} + \text{etc.} \\ &= S(r_h s_k t_l \ldots u_{hkl\ldots}), \end{aligned}$$

where S stands for the summation of all combinations of h, k, $l \ldots$ for all values from 0 upwards.

The calculation of all the r_h, s_k, $t_l \ldots$ terms is done directly from Lagrange's formula and is simple though laborious, and the remainder of the work is mechanical. When the function only depends on two variables the interpolation involves fairly heavy arithmetic if only three values are given to both h and k, while if there are three variables the work could only be completed in two or three hours, and it is therefore clear that if the ordinary one-variable interpolation formula could be used we should save a great deal of arithmetical work.

The ideas underlying the two methods can be seen graphically.

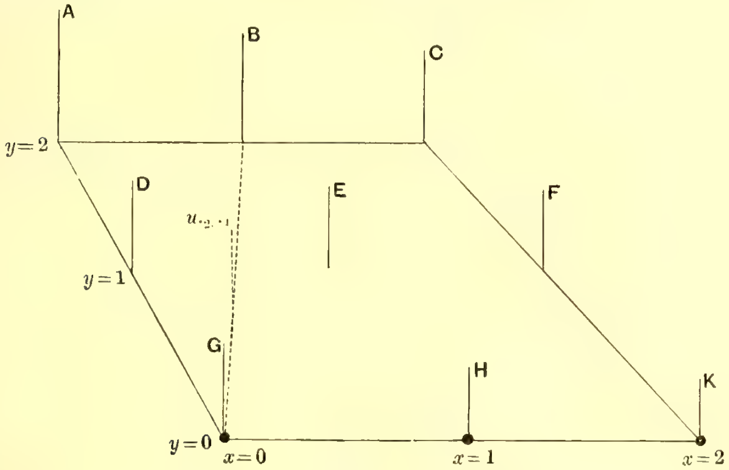

Fig. 2.

In this figure a surface $ACKG$ represents u_{xy}, so that when $x=0$, $y=2$, u_{xy} has the value represented by the height A, and when $x=1$, $y=1$, u_{xy} has the value represented by E. Now if we require to find $u_{\cdot 2, \cdot 4}$ we can approximate to the surface by the $(1+\Delta_x)(1+\Delta_y)$ method or by the Lagrange coefficient method and hence find the particular height we require, or we can choose the positions of two or more values so that the straight line passing through them also passes through the point $x=\cdot 2$, $y=\cdot 4$ and then interpolate by the one-variable formulae between the values of the function corresponding to the points on this straight line. In fig. 2 the line joining $x=0$, $y=0$ to $x=1$, $y=2$ passes through $x=\cdot 2$, $y=\cdot 4$ and by interpolation between B and G we can therefore approximate to $u_{\cdot 2, \cdot 4}$. The dotted lines show the process.

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* W. Palin Elderton in *Biometrika*, Vol. II. Part 1.

† *Journal of the Institute of Actuaries*, Vol. XL. pp. 289—293.

2. *The Interpolation Line Method.* We may now attack the theory of this second method in greater detail.

Let us assume that from the following tabulated terms it is required to find $u_{h,k,l,\dots}$:

$$\begin{array}{llll} u_{0,0,0,\dots}, & u_{r,s,t,\dots}, & u_{2r,2s,2t,\dots}, & \text{etc.,} \\ u_{0,s,t,\dots}, & u_{r,2s,2t,\dots}, & u_{2r,3s,3t,..}, & \text{etc.,} \\ \text{etc.,} & \text{etc.} & & \end{array}$$

This scheme is general and there is no loss of generality in assuming that the interpolated values are for integers, i.e. if the function is tabulated for $x=0$, 5, 10, etc., $y=0$, 8, 16, etc., $z=0$, 2, 4, etc., the interpolated values required would be for $x=1$, 2, 3, 4, etc., $y=1$, 2, 3, ..., $z=1$, 3, 5, ...; because if fractional values are required we can assume that the x's, y's, z's, etc. proceed by larger differences.

Now in order to get u_h we take $\frac{h}{r}$ and use the formula $(1+\Delta)^{\frac{h}{r}} u_0=u_h$, or we can take $\frac{h}{2r}$ and use $(1+\Delta')^{\frac{h}{2r}} u_0=u_h$, where $\Delta=u_r-u_0$ and $\Delta'=u_{2r}-u_0$. Again to get u_{y+k} we take $(1+\Delta)^{\frac{k}{s}} u_0$ or $(1+\Delta')^{\frac{k}{2s}} u_0$ or etc., where Δ and Δ' have similar meanings.

But if $\frac{h}{r}$ be used for a two-variable, then the interpolated function found could be $u_{x+h,\, y+\frac{h}{r}s}$, and therefore in order to get terms from which interpolation can be made we must use, not u_{00}, u_{rs}, etc., but u_{00}, $u_{r\alpha,\, s\beta}$, so that when we take $(1+\Delta_\alpha)^{\frac{h}{r\alpha}} u_{xy}$ we shall get u_{hk}. It is fairly clear that if we can fix either $r\alpha$ or $s\beta$ the other can be obtained easily, and a little consideration of the way the $r\alpha$ and $s\beta$ arise will show the reader that the term can be fixed by the least common multiple of h, r, k and s.

A numerical example will make this clearer. Let $u_{0,0}$, $u_{5,8}$, $u_{10,16}$, etc. be given and assume that we require $u_{2,3}$; then the L.C.M. of 2, 3, 5, 8 being 120 we must interpolate between $u_{0,0}$, $u_{80,120}$, $u_{160,240}$, ..., for having fixed the 120, the proportion to be taken is $\frac{3}{120}=\frac{1}{40}$ and $2\times 40=80$. If a third variable is introduced the same method can be used, and if in our last numerical example we take $u_{0,0,0}$, $u_{5,8,10}$, $u_{10,16,20}$, ... as given, and require $u_{2,3,7}$, we can use $u_{0,0,0}$, $u_{240,360,840}$, $u_{480,720,1680}$, etc. The numerical work would be as follows in an imaginary example:

$$\begin{array}{rcc} & \Delta & \Delta^2 \\ u_{0,0,0}=4872 & -2760 & +1656, \\ u_{240,360,840}=2112 & -1104, & \\ u_{480,720,1680}=1008. & & \end{array}$$

$$\begin{aligned} \therefore\quad u_{2,3,7} &= 4872-\tfrac{1}{120}\cdot 2760-\tfrac{1}{2}\cdot\tfrac{1}{120}\cdot\tfrac{119}{120}\cdot 1656 \\ &= 4832. \end{aligned}$$

There are, of course, many objections to such a method in practice when it entails differences in the independent variable, such as 240, 360 and 840, but it can often be simplified considerably; for instance, in the last example, if we imagine the given values to extend to negative values of x, y and z, we can start from $u_{5,0,10}$ and seek $u_{2,3,7}$. We notice that our fractions are now $\frac{3}{5}$, $\frac{3}{8}$, $\frac{3}{10}$ and the L.C.M. is reduced to 120. The terms to be used are $u_{5,0,10}$, $u_{-115,120,-110}$ and $u_{-235,240,-230}$, and the value of $u_{2,3,7}$ is

$$u_{5,0,10}+\tfrac{1}{30}\left(u_{-115,120,-110}-u_{5,0,10}\right)-\tfrac{1}{2}\cdot\tfrac{1}{30}\cdot\tfrac{29}{30}\ \text{(second diff.)}.$$

In this way we can sometimes diminish the range of values considerably. Even here however a large table would be required for practical work, but it must be borne in mind that a three-variable table is very seldom made, and a two-variable table is frequently simplified by both the x's and y's proceeding by the same difference. The difficulty is however always present to some extent and it would be impossible to find values of u corresponding to a number of decimal places in x, y, ..., though the method might even in these cases be of help as a rough check.

Graphically these examples can be shown very simply by the following figures. Using dots to show the position of given values, then, if the required value is $u_{2,6}$, we join (0, 0) to (2, 6) and produce it till it passes through another point (x', y'), then we can interpolate for $u_{2,6}$ between $u_{0,0}$, $u_{x',y'}$, $u_{2x',2y'}$, etc.

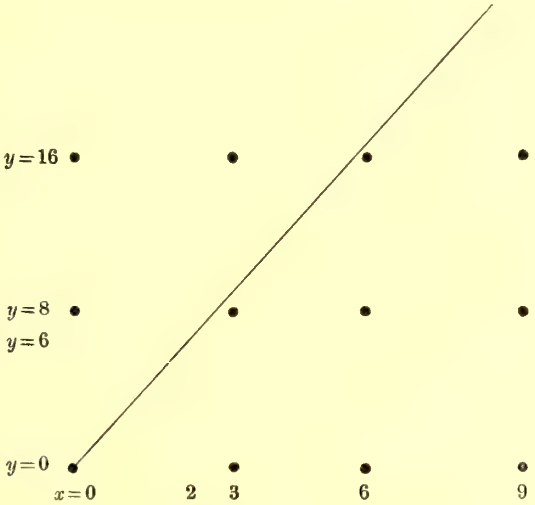

FIG. 3.

In a similar way if there are three variables the following diagram may be constructed, in which dotted lines show those parts of the figure that would not be visible if we had a solid, and the dots show the positions of given values; the "line of interpolation," as it might be called, is *OB*.

In fig. 2 we have represented the surface by giving the heights of the ordinates at the given points, and the same could have been done in fig. 3, but it would have been impossible in fig. 4

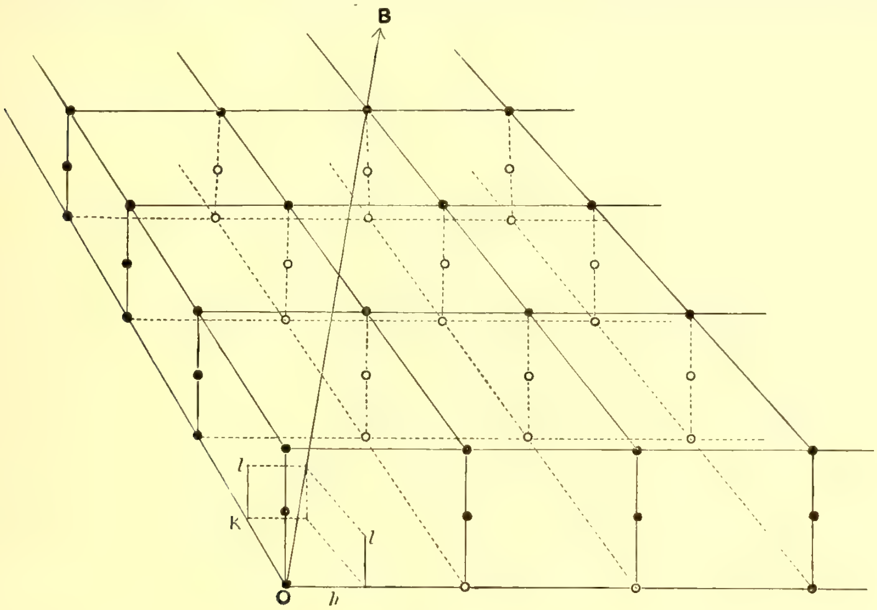

FIG. 4.

because as we are there dealing with a third-dimension body we should require a fourth dimension in order to enable us to represent the values of u_{xyz} as well as their positions. For the same reason we cannot give a graphical illustration of interpolation with four variables.

3. *Some particular cases.* It will probably be useful to give the "interpolation-lines" in the case of a function of two variables where the values proceed by small differences.

We shall assume that only integral values are required, and in our diagrams a heavy dot will stand for the position of a given value and a small dot for the position of a value obtained by interpolation, while the lines show the "interpolation-lines."

Difference in $x = 3$.
" " $y = 3$.

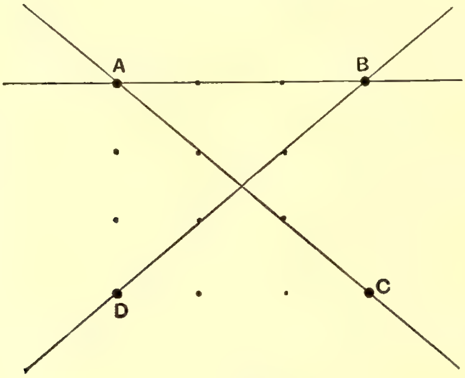

Fig. 5.

In this case the line between AB is an obvious interpolation, and similar lines will be neglected in other diagrams; in fact there is only one "interpolation-line," since AC and BD are the same in principle; they have merely different starting-points.

Difference in $x = 4$.
" " $y = 4$.

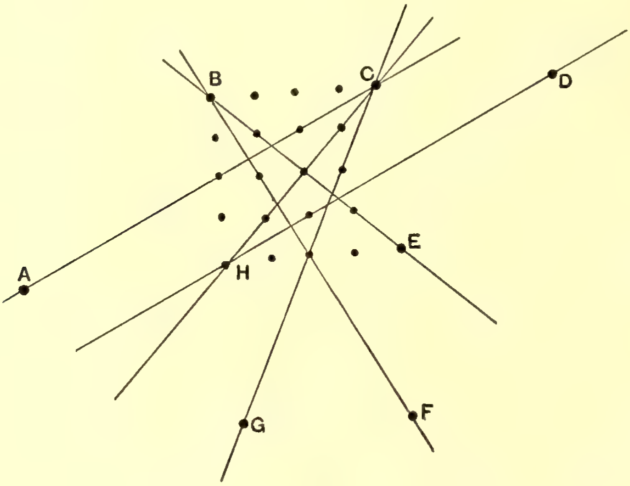

Fig. 6.

In this case there are only two "interpolation-lines," viz. *BE* and *AC*, for *CH* is the same as *BE* and *HD*, *BF* and *CG* are all the same as *AC* with different starting-points; in fact we can in general deal with any half quarter of the square *BCEH* (i.e. half of any one of the triangles formed by two diagonals and a side) and use the results as applicable to all cases.

Example. If we wish to interpolate for $u_{2,1}$ we should take one quarter of the way between $u_{0,0}$ and $u_{8,4}$; if a third term were required we should take either $u_{16,8}$ or $u_{-8,4}$, and the latter would generally be preferred as it is nearer the value required.

Difference in $x = 5$.
" " $y = 5$.

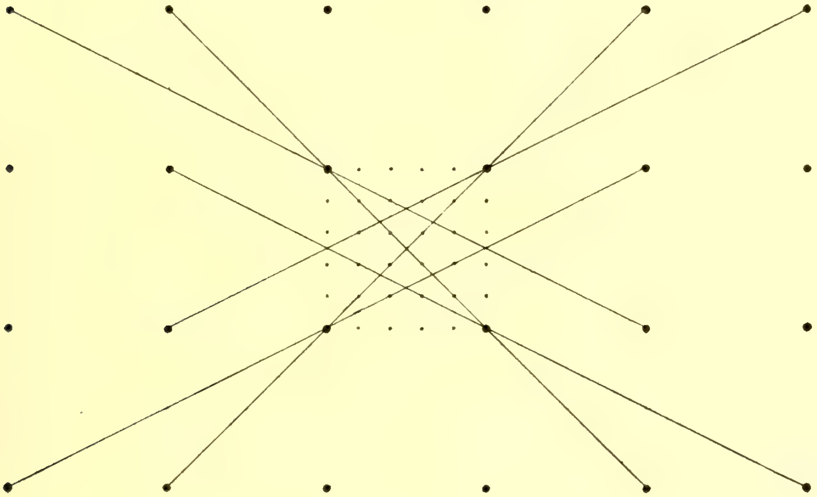

FIG. 7.

This is a very common case and there are only two necessary "interpolation-lines." It will be noticed that there is sometimes more than one line that could give the interpolation, but I have shown the one most likely to give a good result.

Difference in $x = 3$.
" " $y = 2$.

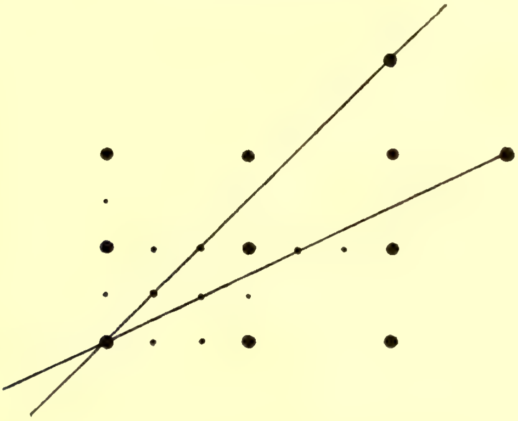

FIG. 8.

In this case in order to obtain an interpolated value for $u_{2,1}$ we require $u_{0,0}$, $u_{6,4}$ and $u_{-6,-4}$; clearly a less useful tabulation than differences of 3 in both x and y, and not much improvement (sometimes it is worse) than differences of 4 in both x and y. The lesson to be learnt from this is that if one can choose one's differences in tabulation it is best to take the same difference in both x and y.

Difference in $x = 10$.
" " $y = 10$.

The diagram in this case becomes rather troublesome, but the following table answers the same purpose.

x	y	Interpolate between	Taking $\frac{n}{10}$ of distance where n is
1	1	0, 0 and 10, 10 I	1
1	2	0, 0 and 10, 20 II	1
1	3	0, 0 and 10, 30 III	1
1	4	10, 10 and −20, −10 IV	3
1	5	0, 0 and 10, 50 V	1
2	2	0, 0 and 10, 10 I	2
2	3	0, 0 and 20, 30 IV	1
2	4	0, 0 and 10, 20 II	2
2	5	0, 0 and 20, 50 VI	1
3	3	0, 0 and 10, 10 I	3
3	4	0, 10 and 10, −10 II	3
3	5	0, −10 and 10, 40 V	3
4	4	0, 0 and 10, 10 I	4
4	5	10, −10 and −10, 40 VI	3
5	5	0, 0 and 10, 10 I	5

This would of course be applicable where one decimal place is required and the tabulation is for integral values, but as will be noticed immediately, the number of independent "interpolation-lines" (see Roman numbers) is very great, and it is not very difficult to show that the decimal system is by no means the best method of tabulating functions. We shall however return to this after showing the application of the above diagrams to numerical work.

4. *Numerical Examples.* The following table gives the values of a function of three-variables, which will enable us to give a few examples.

	$x=45$				$x=50$				$x=55$				$x=60$				
	y				y				y				y				
z	10	15	20	25	10	15	20	25	10	15	20	25	10	15	20	25	30
5	7·24	9·51	12·74	17·71	5·74	7·39	9·60	12·74	4·69	5·93	7·53	9·65	3·95	4·94	6·14	7·66	9·71
10	16·06	21·04	28·20	39·36	12·70	16·27	21·11	28·11	10·34	13·01	16·45	21·13	8·69	10·77	13·33	16·62	21·19
15	26·76	35·03	47·09	66·18	21·08	26·94	35·01	46·90	17·09	21·41	27·06	34·94	14·30	17·61	21·74	27·23	34·97
20	39·73	52·12	70·49	100·00	31·13	39·81	51·99	70·27	25·09	31·39	39·84	51·84	20·86	25·61	31·70	39·95	51·74

Let us first find a value for $x=45$, $y=17$, $z=12$; this only involves two variables, and fig. 7 tells us to interpolate between 45, 10, 5 and 45, 15, 10, etc.; hence the interpolated value required is obtained by ordinary interpolation in the following way:

	Δ	Δ^2	Δ^3
7·24	13·80	12·25	13·61
21·04	26·05	26·86	
47·09	52·91		
100·00			

therefore value is

$$7{\cdot}24+1{\cdot}4\times13{\cdot}80+\frac{(1{\cdot}4)\,({\cdot}4)}{2}\,12{\cdot}25-\frac{(1{\cdot}4)\,({\cdot}4)\,({\cdot}6)}{2\,.\,3}\,13{\cdot}61=29{\cdot}13,$$

while with only three terms we should have obtained 29·89. If we had used the ordinary double-interpolation method with the terms 21·04, 28·20, 47·09 and 35·03, we should have obtained 30·28, and as the true result is 29·48, we have in this case obtained a better approximation by the "interpolation-line" method. The data are not good for interpolation because the differences do not decrease, but this is no disadvantage for our present purpose.

As a second example we will take $x=60$, $y=18$, $z=11$, and we can use 14·30, 13·33 and 9·71 and obtain

$$14{\cdot}30-{\cdot}8\times{\cdot}97+\frac{({\cdot}8)\,({\cdot}2)}{2}\times2{\cdot}65=13{\cdot}73,$$

and the true value is 13·69. Two terms only would have given 13·58. With a little practice the values to be used can be easily picked out.

We will take as our final examples two three-variable cases. To obtain $x=49$, $y=18$, $z=14$ we can use 45, 20, 10 and 55, 15, 20 and take two-fifths of the difference, i.e. $28{\cdot}20+\frac{2}{5}(31{\cdot}39-28{\cdot}20)=29{\cdot}48$, or we can use 50, 20, 15 and 45, 10, 10 thus getting 31·21 while if we add 55, 30, 20 which is 70·02 we get 29·93; the true value is 30·31. To obtain $x=52$, $y=14$, $z=14$ we can use 50, 10, 15 and 60, 30, 10 and obtain 21·10, or we can take 50, 15, 15 and 60, 10, 10 but the former is distinctly preferable and if we add the term 70, 50, 5 which is 17·63 it becomes practically exact.

The latter arrangement, however, shows the method at its worst. The differences run extremely awkwardly and the interpolation by first differences leads to an untrustworthy result. When using the "interpolation-line" method we are, as it were, picking out a level piece of ground on our surface before interpolating; if we choose an uneven piece of ground, i.e. if the differences are large, the result will be inaccurate.

5. *Connection of Method with the Construction of Tables.* An interesting point of some practical importance may now be examined. If we were to make a new two-variable table, what would be the best interval to use if we intended to apply the "interpolation-line" method?

We must clearly use an interval so that the terms used in the interpolations are not far apart, and in order to answer the question it becomes necessary to consider what intervals are most satisfactory from this point of view. We will first see how the various interpolations can be built up and will take the interval 5 to start with. The terms we require to find by interpolation are 1, 1; 1, 2 and 2, 2, because 1, 3 is just the same as 1, 2 but with a different starting point, for it is merely distance 1, 2 from the given term 0, 5. There are therefore only two lines necessary, one symbolised by 1, 1 and showing interpolation between terms like 0, 0 and 5, 5, and the other by 1, 2. The former gives 2, 2; we should have to take two-fifths of the distance between the 0, 0 and 5, 5 given terms instead of the one-fifth that gave 1, 1. Now let us take 7 as an interval. The terms wanted are 1, 1; 1, 2; 1, 3; 2, 2; 2, 3; 3, 3. The 1, 1 line gives 1, 1; 2, 2 and 3, 3; and the 1, 2 line gives 1, 2 and 2, 4, but the second of these is the same as 2, 3 with a different starting-point, and we only therefore require two lines. The idea is easily continued, and it follows that if we use a prime number (p) as our interval, we get with each interpolation line $\frac{p-1}{2}$ cases; but as we require

$$\frac{p-1}{2}+\left(\frac{p-1}{2}-1\right)+\left(\frac{p-1}{2}-2\right)+\ldots=\frac{\left(\frac{p-1}{2}\right)\left(\frac{p-1}{2}+1\right)}{2}$$

cases in all, the number of interpolation-lines required is $\frac{1}{2}\left(\frac{(p-1)}{2}+1\right)$. This gives the following table:

Interval	2	3	5	7	11	13	17	19
No. of lines	1	1	2	2	3	4	5	5

Turning from prime numbers to those containing factors we find at once that many more lines are required. Thus we have already seen that an interval of 10 calls for no fewer than six interpolation-lines, and the intervals of 6 and 8 will both be found to require four. The interval 9 requires three lines.

Let us now compare the 11 interval with the 8 and 10 intervals and see which is the best grouping.

Interval 11.

Ordinary interpolation gives	Line 1, 1 gives	Line 1, 2 gives	Line 1, 3 gives
0, 1	1, 1	1, 2	1, 3
0, 2	2, 2	2, 4	2, 6=2, 5
0, 3	3, 3	3, 6=3, 5	3, 9=3, 2
0, 4	4, 4	4, 8=4, 3	4, 12=4, 1
0, 5	5, 5	5, 10=5, 1	5, 15=5, 4

Average interval in interpolation in x = 8·25

,, ,, ,, ,, ,, y = 15·4

Maximum interval in ... x = 11

,, ,, ,, ... y = 33

Interval 10.

Ordinary interpolation gives	Line 1, 1 gives	Line 1, 2 gives	Line 1, 3 gives		Line 1, 4* gives	Line 1, 5 gives	Line 2, 5 gives
0, 1	1, 1	1, 2	1, 3		1, 4	1, 5	2, 5
0, 2	2, 2	2, 4	2, 6=2, 4	{also by 1, 2 given above	2, 8=2, 2		
0, 3	3, 3	3, 6=3, 4	3, 9=3, 1		3, 12=3, 2	3, 5	6, 5=4, 5
0, 4	4, 4	4, 8=4, 2					
0, 5	5, 5	which has already been obtained					

Average interpolation interval in x = 8·5 or 9·5

,, ,, ,, ,, y = 23·5 or 22·5

Maximum interval in ... x = 20

,, ,, ,, ... y = 50

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* 2, 3 would give the same results and the averages resulting in each case are given.

Interval 8.

Ordinary interpolation gives	Line 1, 1 gives	Line 1, 2 gives	Line 1, 3 gives	Line 1, 4 gives
0, 1	1, 1	1, 2	1, 3	1, 4
0, 2	2, 2	2, 4	2, 6 = 2, 3	
0, 3	3, 3	3, 6 = 3, 2		
0, 4	4, 4			

Average interval in $x = 5{\cdot}71$
„ „ „ $y = 13{\cdot}71$
Maximum interval in $x = 8$
„ „ „ $y = 32$

The interval 9 gives quite a good result, certainly better than 8, but considering the fewer number of values that would be required 11 seems preferable to either, and it is far better than the common decimal interval. When the number representing the interval has factors the "interpolation-lines" do not give as many values as they do when a prime number is used because, owing to the factors, there is repetition.

6. *Conclusions.* The conclusions to which these notes lead us would seem to be

(1) that interpolation can be effected by means of the ordinary one-variable formulae in n-dimension tables;

(2) that the method *can* give reasonably accurate results;

(3) that if the intervals can be chosen, (*a*) the same interval in all the variables will generally be better than different intervals even if the latter are rather smaller, and (*b*) the interval should be given by a prime number.

II. Note on the Relative Variability of the Sexes in Carabus auratus, L.

By H. G. KRIBS.

(*From the Zoological Laboratory of the University of Pennsylvania.*)

The majority of biometrical investigations, which have been made regarding the comparative variability of the sexes as such, seem to have been confined to the human species*. Many observations have been made among lower organisms however, on the existence and variability of secondary sexual characters, or those morphological differentiations, apart from the sexual organs *per se*, by which the male is easily distinguished from the female of the same species. The possible significance of secondary sexual characters for evolution was first pointed out by Darwin†, as suggested by the disproportionate development of these characters in the males and females of the same species where sexual dimorphism is present, and by the difference in behaviour seemingly correlated with it. The data furnished by Darwin covered a wide range in the animal kingdom, and his conclusions have received very general acceptance.

One conclusion reached by Darwin was that in a bisexual species the female ordinarily lies closer to the morphological norm of the species than the male, and that her contribution in reproduction is inherently conservative and tends to maintain the organic stability of the norm. The male, on the other hand, was thought to vary considerably more about the species, norm.

[* The relative variability of the sexes has been dealt with in crabs, wasps, toads and a variety of other published cases, not hitherto collected together, but all tending in much the same direction as in *Carabus auratus*. Ed.]

† *Descent of Man*, Chap. VIII.

Entirely lacking in definite quantitative evidence in its favour, this general point of view regarding the relative variability of the sexes has been widely prevalent among biologists. Now it is obvious that if this generalization is a valid one the general principle involved should find expression, in some measure at least, in all sexual organisms. Whether it does or not, may be determined in a perfectly definite way by application of modern biometrical methods to the analysis of data collected by actual measurement of various characters in individuals of the two sexes.

As a small contribution toward such data, I have determined the chief variation constants of some very carefully collected material presented by Dr A. Porta *. The published data give measurements of fifteen similar characters of 84 males and 84 females of the beetle *Carabus auratus*, L. The characters measured were the following:

(1) Length of body. (2) Maximum breadth of body. (3) Length of head. (4) Width of head. (5) Length of prothorax. (6) Width of prothorax. (7) Length of antenna. (8) Length of first four joints of antenna. (9) Length of anterior leg. (10) Length of median leg. (11) Length of posterior leg. (12) Length of tarsus of anterior leg. (13) Length of mandible. (14) Length of elytra. (15) Length of first joint of antenna.

The measurements are expressed in millimetres.

In the table presented herewith, we have given, in the first column, the mean of each several character with its probable error. In the second column are likewise arranged the standard deviations from the mean of each character with their probable errors. In the third column are given the coefficients of variability and their probable errors.

From the evidence of the means of the fifteen characters measured, four—the length of posterior leg, length of anterior leg, length of tarsus of anterior leg, and total length of antenna—are so nearly equal in length that any difference is more than covered by the probable error. These characters can hardly be held to possess any secondary sexual significance. In these four characters, whose mean size is the same in both male and female, there is, furthermore, no evidence that one sex varies any more than the other. In the case of the anterior leg, the female shows a slight tendency to vary more than the male. This difference is not significant, however.

In all the other characters measured the mean is distinctly larger in the female than in the male, and we may safely assume that these differences represent a greater or less degree of secondary sexual differentiation. In four of these characters—length of first four joints of antenna, length of prothorax, length of head, and width of body—the female shows a higher index of variability than the male. In none of these, however, is the higher rate of variability of real significance, as in no case does it exceed double the probable error.

In the seven remaining characters the male shows a tendency to be more variable than the female. In four of these—length of mandible, length of first joint of antenna, length of body, and width of prothorax—the excess of variability is so slight as not to be appreciable. It is much more than offset by the size of the probable error. In the last three characters the male is probably significantly more variable than the female. In the length of elytra, length of median leg, and width of head, the excess of variability in the male is practically three times the probable error for the same.

On account of the small numbers of individuals taken in each case little emphasis can be laid upon the details of the results noted. It is worthy of consideration, however, that the four characters of equal size in each sex are equally variable, and that in the eleven remaining characters when there is a difference in size between the two sexes, only three show a greater variability in the male than in the female.

The general conclusion can only be, that, so far as the present data indicate, there is no uniform tendency for the individuals of one sex to be more variable than those of the other sex in the beetle, *Carabus auratus*, L.

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* Porta, A., "Le Differenze sessuali secondarii quantitative nel *Carabus auratus*, L." *Bull. Soc. Entom. Ital. Ann.* 34, 1902.

TABLE I.

Character		Mean	S. D.	C. of V.
Length of body		♂ 22·506 ± ·077	1·041 ± ·054	4·62 ± ·24
		♀ 22·851 ± ·081	1·095 ± ·057	4·40 ± ·23
	Difference	·345 ± ·112	·054 ± ·078	·22 ± ·33 ♂
Width of body		♂ 8·994 ± ·030	·410 ± ·021	4·56 ± ·24
		♀ 10·176 ± ·038	·521 ± ·027	5·12 ± ·27
	Difference	1·182 ± ·048	·111 ± ·034	·56 ± ·36 ♀
Length of head		♂ 3·750 ± ·020	·270 ± ·014	7·20 ± ·38
		♀ 4·036 ± ·023	·318 ± ·017	7·89 ± ·41
	Difference	·286 ± ·030	·048 ± ·022	·69 ± ·56 ♀
Width of head		♂ 3·152 ± ·015	·199 ± ·010	6·30 ± ·33
		♀ 3·396 ± ·011	·145 ± ·008	4·25 ± ·22
	Difference	·244 ± ·019	·054 ± ·013	2·05 ± ·40 ♂
Length of prothorax		♂ 4·589 ± ·018	·248 ± ·013	5·40 ± ·28
		♀ 4·946 ± ·021	·289 ± ·015	5·84 ± ·30
	Difference	·357 ± ·028	·041 ± ·020	·44 ± ·41 ♀
Width of prothorax		♂ 6·693 ± ·024	·322 ± ·017	4·82 ± ·25
		♀ 7·292 ± ·024	·332 ± ·017	4·55 ± ·24
	Difference	·599 ± ·034	·010 ± ·024	·27 ± ·35 ♂
Length of elytra		♂ 14·411 ± ·051	·693 ± ·036	4·80 ± ·25
		♀ 16·066 ± ·047	·639 ± ·033	3·98 ± ·21
	Difference	1·655 ± ·069	·054 ± ·049	·82 ± ·33 ♂
Length of anterior leg ...		♂ 15·613 ± ·051	·698 ± ·036	4·47 ± ·39
		♀ 15·589 ± ·056	·766 ± ·040	4·92 ± ·26
	Difference	·024 ± ·076	·068 ± ·054	·45 ± ·47 ♀
Length of median leg		♂ 17·857 ± ·071	·965 ± ·050	5·40 ± ·28
		♀ 18·304 ± ·057	·774 ± ·040	4·23 ± ·22
	Difference	·447 ± ·091	·191 ± ·064	1·17 ± ·36 ♂
Length of posterior leg ...		♂ 24·423 ± ·081	1·099 ± ·057	4·51 ± ·24
		♀ 24·423 ± ·080	1·088 ± ·057	4·46 ± ·23
	Difference	·000 ± ·114	·011 ± ·081	·05 ± ·33 ♂
Length of tarsus of anterior leg		♂ 5·176 ± ·029	3·980 ± ·021	7·68 ± ·40
		♀ 5·176 ± ·029	3·980 ± ·021	7·68 ± ·40
	Difference	·000 ± ·041	·000 ± ·030	·00 ± ·57
Length of antenna		♂ 13·750 ± ·046	·629 ± ·033	4·58 ± ·24
		♀ 13·685 ± ·046	·619 ± ·032	4·52 ± ·24
	Difference	·065 ± ·065	·010 ± ·046	·06 ± ·34 ♂
Length of first four joints of antenna		♂ 5·329 ± ·017	·232 ± ·012	4·36 ± ·23
		♀ 5·483 ± ·020	·269 ± ·014	4·90 ± ·26
	Difference	·154 ± ·026	·037 ± ·019	·54 ± ·35 ♀
Length of first joint of antenna		♂ 2·063 ± ·010	·128 ± ·007	6·10 ± ·32
		♀ 2·128 ± ·009	·122 ± ·006	5·73 ± ·30
	Difference	·065 ± ·013	·006 ± ·009	·37 ± ·44 ♂
Length of mandible		♂ 3·304 ± ·015	·208 ± ·011	6·30 ± ·33
		♀ 3·607 ± ·015	·205 ± ·011	5·63 ± ·29
	Difference	·303 ± ·021	·003 ± ·016	·67 ± ·44 ♂

III. Variation in Flower-heads of Gaillardia Aristata.

By W. W. ROBBINS.

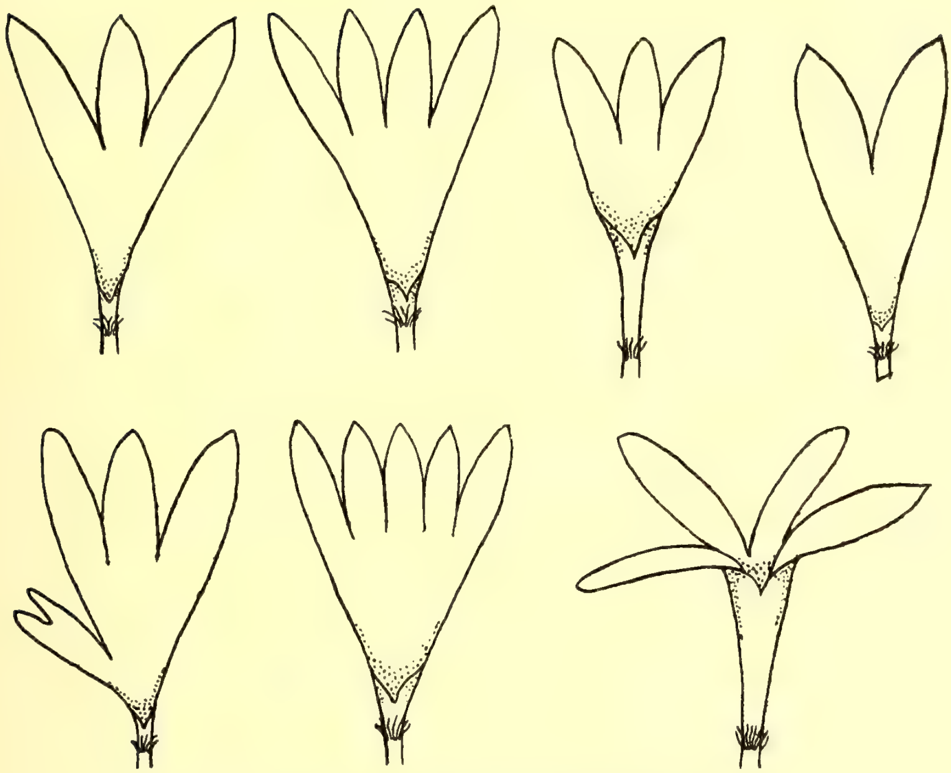
This conspicuous Composite has flower-heads about 6 cm. broad with purplish-brown centres and bright orange rays. In some heads a part of the rays are of the usual length and colour but tubular (*Torreya*, VI. 190, 1906) as was noted by the writer in a previous paper. During the summer of 1907 from July 17 to August 14 a collection of 500 flower-heads was made from localities in the neighbourhood of Boulder.

Gaillardia aristata commonly grows in loose soil where there is not much water. About one-half of the flower-heads studied were, however, collected at an altitude of 9000 feet, from plants growing in an aspen grove. These plants were well-developed and the rays larger than those in plants found growing in the open. Other than this no special variation has been noted in the rays of plants growing in different altitudes and habitats.

Records were made of the number and character of all the ray-flowers in each head studied. A part of the data appear in the following table.

1	*2*	*3*	*4*	*5*	*6*	*7*	*8*
Number of rays in a head	Number of heads	Number of heads with all the rays ligulate	Number of heads with all the rays tubular	Number of heads with mixed ligulate and tubular rays	Percentage of heads with all the rays ligulate	Percentage of heads with all the rays tubular	Percentage of heads with mixed ligulate and tubular rays
9	1	1	0	0	100	0	0
10	8	5	0	3	62	0	38
11	23	16	0	7	69	0	31
12	33	27	0	6	81	0	19
13	123	95	1	27	77·2	0·9	21·9
14	53	40	1	12	75·4	2	22·6
15	47	31	1	15	65·9	2·2	31·9
16	55	41	1	13	74·5	1·9	23·6
17	45	33	0	12	73	0	27
18	33	21	0	12	63	0	37
19	21	14	1	6	66·6	4·9	28·5
20	21	10	0	11	47	0	53
21	8	7	0	1	87	0	13
22	13	6	1	6	46·1	6·8	46·1
23	5	2	0	3	40	0	60
24	4	1	0	3	25	0	75
25	1	0	0	1	0	0	100
26	2	0	0	2	0	0	100
27	0	0	0	0	0	0	0
28	3	0	0	3	0	0	100
33	1	0	0	1	0	0	100
	500	350	6	144	70	1·2	28·8

To illustrate what the table shows the 13-rayed head may be taken as an example. Columns 1 and 2 show that of the 500 heads examined 123 had 13 rays in a head. Column 3 shows that 95 of these had all ligulate rays; Column 4 shows that 1 had all tubular rays; Column 5 shows



Various forms of ray-flowers seen in the flower-heads of *Gaillardia aristata* × 1⅓.

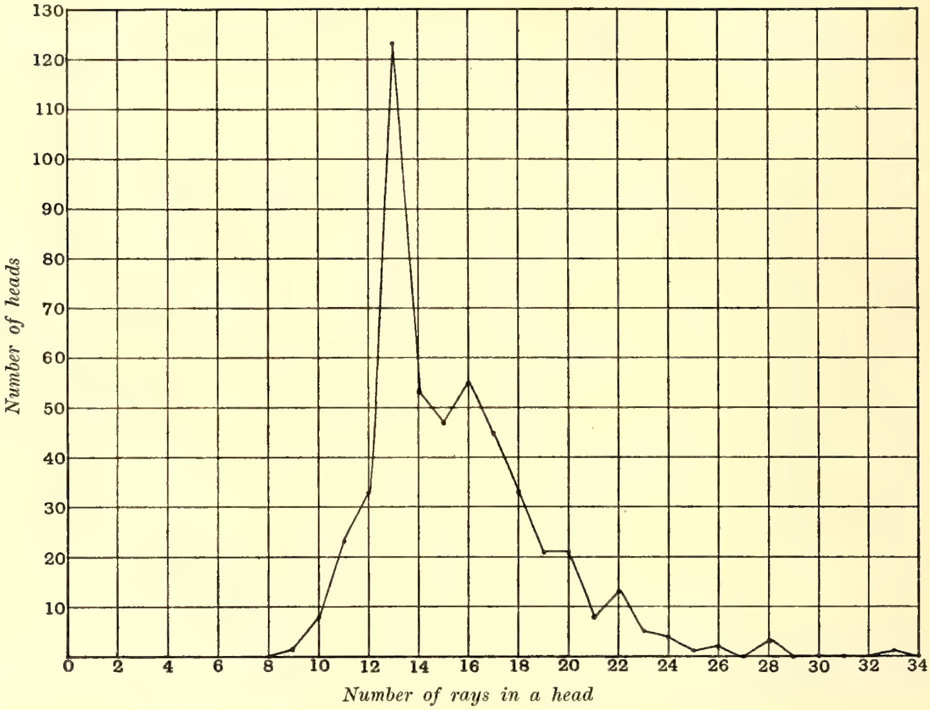
that 27 had mixed ligulate and tubular rays. Columns 6, 7 and 8 deal with percentages; it is seen that 77·2 is the percentage of 13-rayed heads with all ligulate flowers; 0·9 the percentage of 13-rayed heads with all rays tubular, and 21·9 the percentage of 13-rayed heads with mixed tubular and ligulate rays.

It is seen that when the number of rays in a head is large both ligulate and tubular rays are apt to occur. While with fewer rays in a head there are some instances in which all the flowers are tubular and many in which all are ligulate. The normal head has all ligulate rays, but a percentage of 28·8 heads with mixed ligulate and tubular rays shows a strong tendency to vary from this normal.

The accompanying curve of variation for the number of rays is computed from columns 1 and 2 of the foregoing table. It includes all rays without regard to their form. There is a well-developed mode at 13 and the usual skewness to the right which may be expected in all such studies as the present one.

The 500 flower-heads examined had a total of 7709 rays. The larger part of these rays were three-lobed and ligulate but some had as many as six lobes and a single specimen had only one lobe. In the following table the records for all of these flowers are tabulated. It includes therefore both ligulate and tubular rays.

It will be seen from the table on p. 108 that while the ligulate rays have as a rule three lobes, the tubular rays are more often four-lobed. The percentage of ligulate rays decreases and the percentage of tubular rays increases with an increase in the number of the lobes.



Record of 7709 *Ray-Flowers in* 500 *Flower-Heads.*

	f, Ligulate	*f*, Tubular	°/₀ Ligulate	°/₀ Tubular
1-lobed flowers ...	1	0	100	0
2-lobed flowers ...	193	0	100	0
3-lobed flowers ...	5908	146	98	2
4-lobed flowers ...	893	296	75	25
5-lobed flowers ...	78	183	30	70
6-lobed flowers ...	0	11	0	100
	7073	636	92	8

Summary. The normal flower-head of *Gaillardia aristata* has 13 three-lobed ligulate rays. Variation from the normal, however, is common and occurs in the number and form of the rays and in the number of lobes in a ray. The tendency to vary is toward a flower-head having a larger number of rays, mixed ligulate and tubular, the latter being four-lobed. A few heads are found with all the rays tubular.

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[It is worth noting that the Fibonacci mode series (see *Biometrika*, Vol. I. p. 306), namely, 5, 8, 13, 21, 34..., is not represented in the sub-modes of *Gaillardia aristata*; and, except for the primary mode 13, there is no evidence in favour of the Fibonacci doctrine from the data. ED.]

IV. The Effect of Errors of Observation upon the Correlation Coefficient.

By J. A. COBB.

The correlation coefficient $r=\frac{S(xy)}{N\sigma_x\sigma_y}$, where the values of x and y are unaffected by errors of observation. If we assume all the x's and y's to be subject to errors α, β, with standard deviations σ_x, σ_y, the errors of x and y in every pair being independent, $\frac{S(xy)}{N\sigma_x\sigma_y}$ will become

$$\frac{S((x\pm\alpha)(y\pm\beta))}{N\sqrt{(\sigma_x{}^2+\sigma_{x_1}{}^2)(\sigma_y{}^2+\sigma_{y_1}{}^2)}}=\frac{S(xy)}{N\sqrt{(\sigma_x{}^2+\sigma_{x_1}{}^2)(\sigma_y{}^2+\sigma_{y_1}{}^2)}}=r_1.$$

So

$$\frac{r_1}{r}=\frac{\sigma_x\sigma_y}{\sqrt{(\sigma_x{}^2+\sigma_{x_1}{}^2)(\sigma_y{}^2+\sigma_{y_1}{}^2)}}.$$

In the special case where $\sigma_x=\sigma_y$ and $\sigma_{x_1}=\sigma_{y_1}$, $\frac{r_1}{r}$ becomes $\frac{\sigma_x{}^2}{\sigma_x{}^2+\sigma_{x_1}{}^2}$. The correctness of determinations of correlation coefficients has often been considerably affected by the neglect of this point. The question of the inheritance of sex-ratio is an interesting one in this connexion. The sex-ratio of an individual is the value which the ratio of male to total births in his fraternity would tend to assume if his fraternity were infinitely large. The standard deviation of error of sex-ratio due to taking small families is approximately $\sqrt{\frac{pq}{m}}$, where m is the number of the family and p, q the ratios of male and female respectively to the whole in all the families. The total standard deviation of the sex-ratio in families of the same size is due to the deviation $\sqrt{\frac{pq}{m}}$ and to σ_x, the variability of the sex-ratio of families. Therefore

$$\sigma_x=\sqrt{\sigma_0{}^2-\frac{pq}{m}},$$

where σ_0 is the total observed standard deviation. I have in this way calculated σ_x from various data, and it turned out to be between ·03 and ·04. Now in the case of families of nine children $\frac{pq}{m}=\cdot028$. So if the observed sex-proportion is used in forming a correlation table between the sex-ratios of parents and offspring in families of nine, the resulting correlation coefficient must be multiplied by $\frac{\sigma_x{}^2+\frac{pq}{m}}{\sigma_x{}^2}=\frac{(\cdot035)^2+\cdot028}{(\cdot035)^2}=24$ to give the true correlation between the sex-ratios of parents and offspring.

V. On Heredity in Sex. Remarks on Mr Cobb's Note.

By KARL PEARSON, F.R.S.

Mr Cobb's point is an important one, though as a statistician I am never convinced by unpublished statistics which are said to give a certain result. But Mr Cobb's criticism would I think apply to all correlation treatment of inheritance. If we take the male offspring of a father of definite arm-length, their mean based upon four or five cases may differ very widely from the mean of all the offspring the father would have, if we supposed him capable of an indefinite number of offspring. In the same way he himself is only a single random sample from an indefinitely great array which might theoretically be attributed to his parents. I do not see that there is anything more of the nature of "an error of observation" in taking the actual sex-ratio of the offspring as a somatic character, than in taking the actual stature or actual arm-length of the offspring. Neither represents the actual gametic character, if what is meant by that is the mean value for an indefinite number of offspring. What the biometrician is concerned with is the relation between the somatic character *as actually observed* in one generation and again in the next, and for the sex-ratio this relationship is practically zero. In the case of the sex-ratio the variability σ_{x_1} noted by Mr Cobb is not a variability due to error of observation, but a variability characteristic of the species itself being determined by its fertility. According to Mr Cobb it is so great that it renders it impossible to determine for the sex-ratio any relation between the somatic character in parent and offspring. Is this more than a biometrician means when he says that there is no inheritance of the sex-ratio? No process, for example, of selecting families, giving many sons, would alter the sex-ratio, because the mean sex-ratio of families sprung from families with few and families with many sons is sensibly the same. I am not certain, however, that the numerical example given by Mr Cobb, i.e. $\frac{pq}{m} = {}^{\cdot}028$, is correct. For, if p be really an inherited character it may take all values from 0 to 1, and accordingly we shall not get the proper value of this expression by putting $p=q=\frac{1}{2}$, the value which gives the *maximum* value of pq, but by putting pq its actual observed mean value in man; this reduces Mr Cobb's multiplying factor to about a fifth of the value he assumes for it, and such a factor, if it were correct, would not influence the general conclusion. But Mr Heron has applied several further tests to his own data. It will be remembered that for the Whitney data in his memoir on sex inheritance Mr Heron took the sex-ratios in two generations of families having four or more members, the correlation for 2197 families was found to be ·02 ± ·01. From the same data Mr Heron has picked out the 420 families with eight or more members, the correlation is now ·01 ± ·03. Instead of increasing as it ought to do, on the assumption of Mr Cobb, it has got still more insignificant.

But Mr Cobb's note suggests a point which it seemed well worth while working out. If there be no correlation the resulting standard deviation of the material ought to be exactly what would be obtained on the theory of pure chance, i.e. there would be no variation due to heredity superposed on this. Mr Heron has investigated this point for 496 families given by my schedules and for 2305 families taken from the Whitney data. Suppose we take all the n_s families of s members; let m_s be the mean number of males, σ_s the standard deviation of this array, then m_s/n_s and σ_s/n_s will be the mean and standard deviation of the sex-ratios of this array of families of s members. Let $\bar{p}$ be the mean sex-ratio of the whole series of families and σ the standard deviation, then

$$\bar{p}=\frac{1}{N} S\left(n_s \frac{m_s}{n_s}\right) \text{..(i)},$$

$$\sigma^2=\frac{1}{N} S\left[n_s\left\{\left(\bar{p}-\frac{m_s}{n_s}\right)^2+\left(\frac{\sigma_s}{n_s}\right)^2\right\}\right] \text{..............................(ii)}.$$

Now σ_s/n_s is what Mr Cobb puts σ_0, and he makes this differ from his pq/m, so that he obtains a quantity σ_x, which is the variability of the sex-ratio, if the families were indefinitely great, and upon this he tells us the true heredity depends. Accordingly if σ_x be a reality the value found for σ^2 by putting $m_s/n_s=\bar{p}$ and $\sigma_s/n_s=\bar{p}\bar{q}/n$ ought to be *less* than the actually determined value of σ^2. Mr Heron finds the following results:

	Value of σ^2			
Pearson's Schedules	Observed	·1944	Calculated	·1946
Whitney Family	„	·2079	„	·2086

In both cases the calculated value is insensibly *greater* than the observed. In other words σ_x must be imaginary, or rather within the limits of the probable error it is zero. *Shortly, if any individual had an indefinitely large family, the ratio of the sexes would not differ from that of the* *general population, or there is no variability in the sex-ratio due to individuality. All the variation observed is actually due to the random sampling involved in taking small families.*

It appears to me therefore that Mr Cobb's note is of value, as it enables Mr Heron to confirm his results from another standpoint. For practical purposes the main problem is: Are the actual sex-ratios in parent and offspring related? The answer is: Not sensibly. Mr Cobb suggests that this result is only due to the apparent family not representing the gametic reality. This raised the question of whether any individuality at all exists for the sex-ratio. The answer appears to be none, because the standard deviation observed is precisely that which would be found were the sex-ratio for any individual that due to a random selection from the general population of a group equal in number to his family.

VI. On the Influence of Double Selection on the Variation and Correlation of two Characters.

By KARL PEARSON, F.R.S.

In a memoir published in the *Phil. Trans.* Vol. 200 A, pp. 1—66, I have dealt with the problem of the influence of selecting q characters on the variability and correlation of $n-q$ non-selected characters*. My present problem is somewhat different, and as the solution provided has been in use, and given in lectures for some years past, it may be desirable to publish it.

There are two correlated variables, 1 and 2, with standard deviations σ_1 and σ_2 and correlation r_{12}. In entering up a record a selection is made of the variable 1, so that its mean is shifted to m_1 and its standard deviation to s_1; let $\mu_1 = s_1/\sigma_1$. In entering for the variable 2, a selection is made so that its mean is shifted to m_2 and its standard deviation is changed to s_2; let $\mu_2 = s_2/\sigma_2$. As illustration suppose cards formed of characters in parent and offspring; we pass through the cards, putting a red line through every card not one of the selected parents; we pass through them again and put a blue line through every card not one of the selected offspring; the result is that cards may be thrown out because they carry a red line or a blue line or because they carry *both*. The problem is what are the standard deviations Σ_1 and Σ_2 and the correlation R_{12} of the material left after this double selection. If we assume the material normal the following values are readily found by considering the probability of selecting a definite individual pair x_1, x_2 to be of the form

$$\text{const.} \times e^{-\frac{1}{2}\frac{1}{1-r_{12}^2}\left(\frac{x_1^2}{\sigma_1} - \frac{2rx_1x_2}{\sigma_1\sigma_2} + \frac{x_2^2}{\sigma_2^2}\right)} \times \frac{e^{-\frac{(x_1-m_1)^2}{2s_1^2}}}{e^{-\frac{x_1^2}{2\sigma_1^2}}} \times \frac{e^{-\frac{(x_2-m_2)^2}{2s_2^2}}}{e^{-\frac{x_2^2}{2\sigma_2^2}}}.$$

Thus the correlation surface is:

$$z = \text{const.} \times e^{-\frac{1}{2}\frac{1}{1-R_{12}^2}\left\{\frac{(x_1-M_1)^2}{\Sigma_1^2} - \frac{2R_{12}(x_1-M_1)(x_2-M_2)}{\Sigma_1\Sigma_2} + \frac{(x_2-M_2)^2}{\Sigma_2^2}\right\}}.$$

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* It may be of interest to note that the whole of the formulae developed in that memoir are true far beyond the range of the Gaussian distributions for which they were proved. They are universally true provided we start with a generalised notion of correlation as involving the maximum dependence of one variable on an arbitrary linear function of $(n-1)$ other variables.

Hence we deduce:

$$\Sigma_1^2 = \sigma_1^2 \frac{\mu_1^2 \{1 - r_{12}^2 (1 - \mu_2^2)\}}{1 - r_{12}^2 (1 - \mu_1^2)(1 - \mu_2^2)} \quad \text{.........(i)}$$

$$\Sigma_2^2 = \sigma_2^2 \frac{\mu_2^2 \{1 - r_{12}^2 (1 - \mu_1^2)\}}{1 - r_{12}^2 (1 - \mu_1^2)(1 - \mu_2^2)} \quad \text{.........(ii),}$$

$$R_{12} = r_{12} \frac{\mu_1 \mu_2}{\sqrt{1 - r_{12}^2 (1 - \mu_1^2)} \sqrt{1 - r_{12}^2 (1 - \mu_2^2)}} \quad \text{.........(iii),}$$

$$\frac{M_1}{\sigma_2} = \frac{m_1}{\sigma_1} \frac{1 - r_{12}^2 (1 - \mu_2^2)}{1 - r_{12}^2 (1 - \mu_1^2)(1 - \mu_2^2)} + \frac{m_2}{\sigma_2} \frac{\mu_1^2 r_{12}}{1 - r_{12}^2 (1 - \mu_1^2)(1 - \mu_2^2)} \quad \text{.........(iv),}$$

$$\frac{M_2}{\sigma_2} = \frac{m_1}{\sigma_1} \frac{\mu_2^2 r_{12}}{1 - r_{12}^2 (1 - \mu_1^2)(1 - \mu_2^2)} + \frac{m_2}{\sigma_2} \frac{1 - r_{12}^2 (1 - \mu_1^2)}{1 - r_{12}^2 (1 - \mu_1^2)(1 - \mu_2^2)} \quad \text{.........(v).}$$

These formulae will be found useful (especially in deducing r_{12} from R_{12}) in records in which there has been independent selection of two related individuals, without regard to their relationship.

VII. On certain points concerning the Probable Error of the Standard Deviation*.

By RAYMOND PEARL.

The purpose of this paper is to discuss two problems of considerable practical importance in all biometrical investigations. These problems presented themselves in acute form in some studies of fecundity which the writer has at present under way. It was decided to be necessary to get definite answers to them before going farther with the work mentioned. In the belief that the matter is of general interest to workers in biometry it is presented here. The two points may be stated as follows:

I. It has been shown† that if in any frequency distribution σ_{μ_q} be the standard deviation for errors in the qth moment coefficient μ_q, taken about the mean, and σ be the standard deviation of the distribution, then

$$\sigma_{\mu_q} = \sqrt{\frac{\mu_{2q} - \mu^2_q - 2\mu_{q+1}\mu_{q-1} + q^2 \sigma^2 \mu^2_{q-1}}{n}},$$

where n denotes the number in the sample. In this expression put $q = 2$, and then, since $\mu_1 = 0$, we have at once

$$\text{Probable error of } \mu_2 = \cdot 67449 \sqrt{\frac{\mu_4 - \mu_2^2}{n}}.$$

Further since $\sigma = \sqrt{\mu_2}$, we have

$$\text{P.E. of } \sigma = \cdot 67449 \sqrt{\frac{\mu_4 - \mu_2^2}{4\mu_2} \Big/ n} \quad \text{.........(i).}$$

This is the true value of the probable error designated, whatever be the type of the frequency curves. But, for the normal curve, since there $\mu_4 = 3\mu_2^2$, (i) reduces at once to

$$\text{P.E. of } \sigma = \cdot 67449 \sqrt{\frac{1}{2n}}\, \sigma,$$

or as it is usually written

$$= \cdot 67449 \frac{\sigma}{\sqrt{2n}} \quad \text{.........(ii).}$$

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[*] Papers from the Biological Laboratory of the Maine Agricultural Experiment Station, No. 1.

[†] *Biometrika*, Vol. II. p. 276.

Now this value (ii) is the one almost universally used in calculating the probable error of the standard deviation, quite without regard to the type of the distribution under discussion. Indeed one suspects, from statements made in memoirs and handbooks of biometrical methods, that the impression prevails among biologists that (ii) is the true and unique expression for this probable error in every case. Obviously (i) will not equal (ii) except in the special case of the normal curve. In the common use of (ii) for (i) it is, of course, assumed, consciously or unconsciously, that the deviation of the curve from normality is not such as to cause, for *practical* purposes, any significant error as far as these probable errors are concerned. So far as the writer is aware no one has attempted to test in a concrete way the validity of this assumption in specific instances. Yet the matter is obviously a very important one. Probable errors lie at the very basis of all biometrical reasoning. If in certain cases the probable errors are likely to be considerably in error when calculated in a certain way, any reasoning based upon them will have a most insecure foundation.

These considerations suggest the following practical problem to the working biometrician: When a frequency curve is *not* a normal curve, is the error made in the probable error of the standard deviation by assuming normality (using (ii) for (i)) ever likely to be great enough to be of *practical* significance in drawing conclusions from data? This is our first problem.

II. It has recently been pointed out by Sheppard* that in calculating the probable errors of the mean and standard deviation it is theoretically not justifiable to use the moments to which his corrections have been applied. Instead the "raw" moments should be used. The theory of this is stated as follows by Sheppard (*loc. cit.*), μ being used to denote corrected and π to denote raw moments: "Similarly if we take μ_2 to be equal to $\pi_2' - \frac{1}{12}h^2$, where π_2' is the value of π_2 as calculated from the actual measurements, the error in μ_2, due to the limitation of number of observations, is equal to the error in π_2; and the mean square of this latter error is $(\pi_4 - \pi_2^2)/n$. Hence the probable error in the standard deviation will be, not

$$\cdot 67449 \sqrt{\frac{\mu_4 - \mu_2^2}{4\mu_2} \Big/ n} \quad \text{.......................................(iii)},$$

but

$$\cdot 67449 \sqrt{\frac{\pi_4 - \pi_2^2}{4\mu_2} \Big/ n} \quad \text{.......................................(iv)."}$$

Now while it is clear that *theoretically* the uncorrected moments should be used, will it *practically* make any significant difference in the results if the probable errors of the mean and standard deviation are calculated from the corrected moments? This is our second problem.

To get a "working" answer to these two questions it was decided to calculate for a series of curves the probable error of the standard deviation by each of the different methods possible. These possibilities are, of course, first to calculate the probable error by (i) with (*a*) corrected and (*b*) "raw" moments, and then by (ii) using again the corrected and "raw" values of σ successively. With these results in hand for a number of curves we shall be able to form a practical judgment of the necessity or desirability of using the more refined methods in ordinary biometrical investigations. In choosing curves on which to make these tests it was decided to take a rather extreme example of each of Pearson's six types of curves. We may thus expect to get some idea of the maximum effect produced by calculating the probable error under discussion in the several different ways.

The curves actually chosen for the work were the following:

Type I. Curve for variation in leaf number of whorls on "all branches" of certain *Ceratophyllum* plants†. This is an extreme example of a skew curve of Type I. It is figured on p. 34 of the memoir cited.

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* *Biometrika*, Vol. v. p. 455, 1907.

† Pearl, R., Pepper, O. M., and Hagle, F. J. "Variation and Differentiation in Ceratophyllum." Carnegie Institution of Washington, *Publication* No. 58, p. 32.

Type II. A curve from some unpublished material in the hands of the writer.

Type III. Curve of frequency of barometric heights, Churchstoke station[*]. This curve is figured as Fig. V, of Plate II, of the memoir cited.

Type IV. Curve of variation in length of the carpopodite of leg III in the crayfish *Cambarus propinquus* Girard[†].

Type V. Curve of variation in the number of lips in the medusa, *P. pentata*[‡]. The curve is figured on p. 456 of the memoir cited.

Type VI. Curve of variation in leaf number in main stem whorls of *Ceratophyllum*[§]. The curve is figured on p. 34 of the memoir cited.

Certain of the constants of these curves are given in Table I. From the constants it will be seen that all these curves differ widely from the normal or Gaussian curve. Taken as a whole they are fairly representative of the conditions which one finds in frequency curves in practice when large numbers of individuals are dealt with. It will be noted that in some of these curves as tabled, Sheppard's corrections of the moments have been used, while in other cases they have not.

TABLE I. *Constants of Curves.*

Constant	Curve of Type I	Curve of Type II	Curve of Type III	Curve of Type IV	Curve of Type V	Curve of Type VI
N	1954	275	4018	283	996	374
Unit of grouping	1 leaf	15	1/10 in.	3/10 mm.	1	1 leaf
μ_2	1·5350	6·3761	12·6642	7·2794	·3090	·8798
μ_4	5·8052	111·2316	511·4453	246·7453	1·1817	4·0691
β_1	·2112	·0008	·1258	·7276	4·1683	1·1928
β_2	2·4637	2·7360	3·1889	4·6565	12·3760	5·2568
κ_1	–1·7060	– ·5303	+ ·0005	+ 1·1302	+ 6·2469	+ ·9354
κ_2	– ·1002	– ·0011	+198·5780	+ ·5738	+ 1·0659	+1·2455
σ[‖]	1·2390	37·8765	·3559	·809	·5559	·9380
Skewness	– ·6119	– ·0171	+ ·1773	+ ·3293	– ·5294	– ·4270
Sheppard's corrections	Not used	Used	[¶]	Used	Not used	Not used

We may turn now to the consideration of our first problem. Taking the values of the moments given in Table I for the six curves I have calculated the probable error of the standard deviation for each curve, first according to equation (i) above, and then according to equation (ii). It will be noted that this procedure takes no account of whether Sheppard's corrections have been applied to the moments of the several distributions. It is here assumed that (i) is the absolutely true formula in every case. The results are shown in Table II. This table further gives the absolute differences for each pair of probable errors calculated in the two ways. Finally an expression of the relative magnitude of the error made by the use of the approximate formula was obtained by finding in each case what percentage of the true probable error the approximate one was and then subtracting the percentage from 100. The figures so obtained are given in the last line of the table opposite the entry "Relative Error."

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[*] Pearson, K., and Lee, A. *Phil. Trans.* Vol. 190, A, pp. 423—469, 1897.

[†] Pearl, R., and Clawson, A. B. "Variation and Correlation in the Crayfish." Carnegie Institution of Washington, *Publication* No. 64, p. 7, Table I.

[‡] Pearson, K., *Phil. Trans.* Vol. 197, A, p. 455, 1901.

[§] Pearl, Pepper, and Hagle. *Loc. cit.* p. 32.

[‖] Given throughout in concrete units, not in units of grouping.

[¶] The moments in this case were corrected by considering the frequency areas as trapezia. Cf. Pearson, *Phil. Trans.* Vol. 186, A, p. 350.

TABLE II.

Probable Errors of Standard Deviations.

P. E. of σ	Curve of Type I	Curve of Type II	Curve of Type III	Curve of Type IV	Curve of Type V	Curve of Type VI
Calculated by (i) ...	·0114	1·0149	·0028	·0310	·0200	·0337
Calculated by (ii) ...	·0134	1·0893	·0027	·0229	·0084	·0231
Absolute Difference ...	− ·0019	− ·0644	+ ·0001	+ ·0081	+ ·0116	+ ·0106
Relative Error ...	17 °/₀	7 °/₀	4 °/₀	26 °/₀	58 °/₀	31 °/₀

From this table we note at once the following facts:

(*a*) As was to be expected the approximate formula for P.E. of σ in the case of these skew curves never gives the true value.

(*b*) The probable error obtained by the approximate formula may be either in excess or defect of the true value.

(*c*) The amount of the deviation of the approximate from the true value varies in the different curves but may be very considerable. Thus in the case of Type V curve the probable error from the approximate formula is less than half as large as it should be. In the Type VI curve the approximate value is but 69 °/₀ of the true, and the Type IV curve 74 °/₀. It will be noted that not only are these deviations of the approximate from the true values large in amount, but further they are in the direction most likely to cause serious error in practical biometrical work. It is not so serious a matter when an approximate formula makes a probable error too large as when it makes it too small.

(*d*) In the case of the curves of Types I, II and III the deviations of approximate from true values are all small, and in the first two cases the approximate value is in excess of the true. So far as we may judge from the curves here discussed, it would appear that the most serious difficulty from the use of the approximate probable error formula is to be expected in curves of Types IV, V and VI. Thinking that possibly the great deviations observed in the case of Type V and VI curves might be exceptional and due to the particular examples chosen, I took another Type VI curve and calculated the P.E. of σ as before. This curve is one discussed by Pearson (*Phil. Trans.* Vol. 197, A, p. 451). It gives the variation in age of the brides in 28,454 Italian marriages. The values of the moments indicate a curve of Type VI but the criterion κ_2 is so nearly 1 that a Type V curve gives a good graduation. The results of the probable error calculations (using corrected values of the moments) are shown in the following table:

P. E. of σ	Curve of Type VI
Calculated by (i) ...	·0177
Calculated by (ii) ...	·0103
Absolute Difference ...	+ ·0074
Relative Error ...	42 °/₀

We see here just as before that the approximate value is largely in defect of the true value.

(*e*) Considering Table II in connection with Table I it is evident that there is no simple relation between what I have called the "Relative Error" and any of the constants of the curves. That is to say, even though we know the ordinary constants of a given curve it will not be possible to say beforehand whether the approximate formula for the P.E. of σ will give a reasonably good value in that case.

Taking into account all these facts I think there can be no doubt regarding the answer to our first question. The answer definitely is that when a distribution is not closely normal, there *is* a considerable likelihood that the assumption of normality made in calculating the probable error of the standard deviation by the approximate formula may introduce an error great enough to be of practical importance in drawing conclusions. Whenever a piece of biometric work involves the comparison of standard deviations to determine whether they are significantly different among themselves great caution should be exercised about making conclusions depend on probable errors calculated by the approximate formula.

We may now turn to the consideration of our second problem (cf. p. 113 *supra*). In attempting to get at an answer to it the plan was to calculate for each of the curves given in Table I (with the exception of the Type III curve) the probable error of σ first according to equation (iv) and then according to equation (iii), using, of course, the proper values of μ and π. The same calculations were also made for the curve obtained from the Italian marriage statistics (Type VI) cited above. The results of these computations are set forth in Table III. The "Relative Errors" in this case are obtained as before by taking the percentage which the approximate is of the absolutely true value and subtracting this percentage from 100.

TABLE III.

Probable Errors of Standard Deviations. Influence of Sheppard's Correction.

	Curve of Type I	Curve of Type II	Curve of Type IV	Curve of Type V	Curve of Type VI	Curve of Type VI (Italian Marriages)
$\cdot 67449\sqrt{\frac{\pi_4-\pi_2^2}{4\mu_2}\Big/ n}$	·0118	1·0301	·0312	·0234	·0355	·01775
$\cdot 67449\sqrt{\frac{\mu_4-\mu_2^2}{4\mu_2}\Big/ n}$	·0108	1·0149	·0310	·0226	·0340	·01771
Difference ...	+ ·0009	+ ·0152	+ ·0002	+ ·0009	+ ·0015	+ ·00004
Relative Error ...	7·8 $^\circ/_\circ$	1·5 $^\circ/_\circ$	0·6 $^\circ/_\circ$	3·8 $^\circ/_\circ$	4·2 $^\circ/_\circ$	0·2 $^\circ/_\circ$

From this table we note:

(*a*) That the absolute differences resulting from calculating the probable errors in the two different ways are in every case very small. In only one case (the Type II curve) is the absolute difference greater than 1 in the third decimal place. Now it is, of course, obvious that in ordinary statistical work the probable errors will very rarely be tabled to more than the third place of figures. It would appear then, from the absolute differences here, that the error made by using the approximate formula (iii) instead of (iv) is for *practical* purposes insignificant.

(*b*) Relative to the magnitude of the probable errors themselves the differences are very small. It is seen from the last line of the table that approximately 8 $^\circ/_\circ$ is the maximum relative error made and in the majority of cases the relative error is much smaller than this.

From these results the answer to our second question is, I think, clear, and may be stated in the following way: it is *not* a matter of practical significance in ordinary statistical work that the raw moments be used to calculate the probable error of a standard deviation which has itself been deduced from a moment to which Sheppard's correction has been applied. The error made by using equation (iii) instead of equation (iv) is not likely in the great bulk of ordinary biometrical work ever to reach the magnitude where it will be of any *practical* consequence whatever. One should, of course, always keep in mind the existence of this source of error, and if very fine, close work is to be done take pains to eliminate it. It is obvious, however, that the occasions where it will have to be taken into account will be extremely rare.

Putting all our results together we may summarily state the practical conclusion as follows:

In calculating the probable error of the standard deviation of frequency distributions which deviate sensibly from the normal curve, great caution must be exercised in using the customarily applied formula for this probable error $\left(\cdot 67449 \frac{\sigma}{\sqrt{2n}}\right)$. The use of this approximate formula is not unlikely to lead to serious error when standard deviations are compared on the basis of their probable errors. It will be safest, in the absence of special investigation of the point, for each curve or group of curves under treatment, to calculate the probable error of σ by the formula $\cdot 67449 \sqrt{\frac{\mu_4 - \mu_2^2}{4\mu_2} \Big/ n}$. In using this formula for the probable error it is practically immaterial whether the moments used have or have not been corrected according to Sheppard's formulae.

[*Note.* The standard deviation of the standard deviation σ is known to be $\frac{\sigma}{\sqrt{2n}} \sqrt{1 + \frac{1}{2}\eta}$, where η is the kurtosis $= \beta_2 - 3$. For η small the multiplying factor is $1 + \frac{1}{4}\eta$, and supposing we may neglect for practical purposes an error of $5\,^\circ\!/_\circ$ in a probable error, we conclude that the ordinary formula may be applied as long as the kurtosis lies between $\pm \cdot 2$ or for $\beta_2 = 2 \cdot 8$ to $3 \cdot 2$. This agrees with Dr Pearl's Table II, where only the curve of Type III has its kurtosis within this range. Thus the kurtosis alone, independently of the type, settles whether the ordinary formula is sufficient or not. A further point not yet discussed but of some importance is the significance of the "probable error" at all when we are taking the standard deviation of standard deviations in the case of very skew material. How far does the distribution of standard deviations follow a normal curve? The answer depends largely, I think, on the size of the sample, and the deduction of conclusions from the "probable error" of σ may lead to greater error than even neglecting η, unless we are fairly certain that our σ follows a normal distribution. See the paper by "Student" in the present number of this Journal. K. P.]

VIII. Addendum to Memoir: "Split-Hand and Split-Foot Deformities."

Biometrika, Vol. VI. pp. 26—58.

Since the final proof sheets of the above paper were sent to press, several papers have appeared to which reference is necessary.

The evidence of the Bateson School to show that Mendelism is applicable to deformities in man was criticised in the memoir. At that time stress had been laid on three family trees, that of Farabee, an instance of hypophalangia, and those of Nettleship, instances of congenital cataract. The tendency for the deformity to abate in successive generations was noted, for in these families the last generation in each is the only one which shows the undeformed out-numbering the deformed. The criticism was justified in that the three families had been repeatedly made use of to support the view criticised. Another family of "brachydactyly" is now instanced by Punnett (*Proc. Roy. Soc. of Med.* Feb. 28, 1908), who states that "no member of a brachydactylous family who is free from the defect can transmit it to his or her offspring." For certain families this conclusion might be justified from a consideration of the facts, and apart from the question of Mendelism. But that it is of general applicability is disproved by the family recorded by Hasselwander (*Zeitschr. f. Morph. u. Anthrop.* Bd. 6, 1903, S. 510—526), in which such transmission actually occurs. Drinkwater in the article referred to by Punnett (*Proc. Roy. Soc. Edin.* Vol. 28, 1908, p. 38), states, that of 75 descendants of abnormal parents in the family he records, 39 were abnormal, "a result corresponding with what we should expect from Mendel's law." The statement is misleading, for it implies that 36 of the offspring were normal. As a matter of fact four of these were uncertain, and there is as much reason to consider the ratio 43 to 32, as 39 to 36. The mean, 41 to 34, is the fairest expression of the ratio, and it shows the hyperdominance of the deformed, common to so many malformations.

In regard to the possibility of stability of a deformity, the Nettleship family is of interest (*Ophthalm. Soc. Trans.* Vol. 27, p. 269), in that "night-blindness" has been traced through nine generations and shows no marked tendency to abate. A single instance of this character, though suggestive, does not constitute proof; and in any case the conclusion could be applied solely to "night-blindness."

The point which requires emphasis is that a statement to the effect that a family of brachydactyly is an example of Mendelian heredity (Punnett, *loc. cit.*), or the inclusion of that deformity in lists which purport to show examples of instances in which Mendelism has been witnessed (Bateson, *Progress. Rei Botan.* 1906), is not justified by present evidence*. It may be, and very probably is, the case, that Mendelism applies to certain hereditary human deformities; but the conclusions which are being drawn, or implied, conclusions having a serious sociological aspect, are at present ahead of the facts at our disposal.

THOMAS LEWIS.

IX. On a Formula for Determining $\Gamma(x+1)$.

EDITORIAL.

The statistician so often requires the value of the Γ-function, or more usually the value of $\Gamma(x+1)/(x^x e^{-x})$, that a suggestion as to a ready means of determining it may not be out of place. Every biometrician may be supposed to have at hand Barlow's tables and an arithmometer of some form. The usual series, Stirling's or the Bernoulli number formula, involve inverse powers of x, and thus do not lend themselves to rapid calculation in cases where x may involve three or four figures. Forsyth's formula, i.e.

$$\Gamma(x+1)=\sqrt{2\pi}\left\{\frac{\sqrt{x^2+x+\frac{1}{6}}}{e}\right\}^{x+\frac{1}{2}} \quad\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\text{(i)},$$

is very accurate. It may be read for our purposes as

$$\log\frac{\Gamma(x+1)}{x^x e^{-x}}=0\cdot181{,}9427+\tfrac{1}{2}(x+\cdot5)\log\{(x+\cdot5)^2-\tfrac{1}{12}\}-x\log x \quad\ldots\ldots\ldots\ldots\text{(ii)}.$$

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* Those interested should refer to Joachimsthal (*Virch. Archiv*, 1898, Bd. 6, S. 429). It is obvious from his paper that so-called hypophalangia or brachydactylia is a by no means simple malformation, and is possibly not an entity at all. The number of digits affected and the grade of affection is open to wide variation. There is an instance in the paper (Fall 1), of a symmetrical affection of two fingers, transmitted through a normal individual. Ammon (*loc. cit.* S. 96), quotes the Kellie family, in which hypophalangia is said to have passed through ten generations, and shown sex limitation in transmission.

In this case a square has to be formed, a difference taken, two logarithms looked out, and two multiplications by separate factors undertaken. It is an advantage for arithmometer work that our multipliers should remain the same, especially if a series of values of the function have to be tabled. I accordingly suggest the following formula

$$\log \frac{\Gamma(x+1)}{x^x e^{-x}} = 0{\cdot}399{,}0899 + \tfrac{1}{2}\log x + {\cdot}080{,}929 \sin \frac{25^\circ{\cdot}623}{x} \quad \text{..................(iii).}$$

The advantages of this formula are: (i) the multiplying factors are constants, (ii) the factor $\frac{1}{2}$ can be applied in taking out the logarithm, (iii) the reciprocals of x are tabled, whereas the inverse powers are not, (iv) all the terms are to be added, which saves some liability to error.

I have slightly adjusted the constants of the sine term, so that the multiplying factors are fairly simple and for low values of x tend to allow for the neglected $\frac{1}{x^5}$ term. The calculation requires: one use of Barlow's tables, one use of a logarithmic table, and one of a table of natural sines, with two applications of the arithmometer.

As illustration take $x = 7{\cdot}75$.

Barlow: $\frac{1}{x} = {\cdot}129{,}0323$.

Arithmometer: $\cdot 129{,}0323 \times 23^\circ{\cdot}623 = 3^\circ{\cdot}306195 = 3^\circ\ 18'{\cdot}3717$ at sight.

Table of Natural Sines: $\sin 3^\circ\ 18'{\cdot}3717 = {\cdot}057{,}6719$.

Arithmometer: $\cdot 080{,}929 \times {\cdot}057{,}6719 = {\cdot}004{,}6673$.

$$\text{Accordingly, } \log \frac{\Gamma(x+1)}{x^x e^{-x}} = \left\{ \begin{array}{l} {\cdot}399{,}0899 \\ {\cdot}444{,}6509 \\ {\cdot}004{,}6673 \end{array} \right\} = {\cdot}848{,}4081.$$

Since $\log x^x e^{-x} = {\cdot}848{,}4081$, we have $\log \Gamma(x+1) = 4{\cdot}374{,}7139$.

Working with 7-figure logarithms only, and using the reduction formula and Legendre's Tables, I find $\log \Gamma(x+1) = 4{\cdot}374{,}7140$, which agrees absolutely within the limits of error of the 7-figure tables.

For this particular value of x, Formula (ii) gives $\log \Gamma(x+1) = 4{\cdot}374{,}7105$, not quite so good an agreement.

Generally Formula (iii) is in error in the value of $\Gamma(x+1)$ 1 in 50,000 for $x = 2$, 1 in 900,000 for $x = 6$, and correct to 7 figures if $x = 10$. It is thus more than sufficient for all statistical purposes, where 1 in 1000 is quite a permissible difference with the usual values of the probable errors. For the case of $x = 2$, the worst possible: $2! = \Gamma(3)$ is given as 1·99996 instead of 2. Formula (i) gives 1·99948.

We may, I think, safely conclude that Formula (iii) gives the Γ-function throughout the whole range of the variable * with an adequacy more than sufficient for statistical purposes, and with extremely little numerical labour.

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* Of course Legendre's Tables must still be used for x below unity.

X. Inheritance of the Sex-Ratio in the Thoroughbred Racehorse.

By DAVID HERON, M.A.

Mr Cobb in his note in the *Miscellanea* of this number has defined the sex-ratio of an individual as the value which the ratio of male to total births tends to assume when his fraternity becomes indefinitely large.

It is suggested that the variability, σ_0, actually observed in the sex-ratio as calculated in the ordinary way, arises in part from the variability in what he calls the true sex-ratio, σ_x, and in part from the error due to considering small families, $\sqrt{\frac{pq}{n}}$, and further that the true correlation between the sex-ratios of parent and offspring can be found by multiplying that obtained from considering the actual families by a factor $(\sigma_x^2 + pq/n)/\sigma_x^2$.

It has already been shewn that σ_x is zero, within the limits of probable error, in the case of man. We can however test the reality of this factor directly by two methods. We can compare the correlation found by considering any group of families with that found after rejecting the smaller families, or we can compare the correlation found by considering large completed families with that found from sex-ratios defined by, say, the first four members of these families. In each case, the larger families ought to give higher correlation. The results of the first test have already been given in Prof. Pearson's note. To apply the second test, 1000 mares were taken at random from The General Stud Book, and the sex-ratio of their produce and that of their dam calculated. Only those cases were considered where each mare had at least eight foals, and as only second and subsequent editions of the Stud Book were used, the sex-ratio in each case was based on a *completed* family. From the same families sex-ratios were also calculated from the first four members. Tables I and II give the actual correlation tables

TABLE I.

Correlation of Sex-Ratios of Mother and Daughter Mares' Produce: Completed Families. Thoroughbred Horses from The General Stud Book.

Sex-Ratios of Daughters' Produce.

Sex-Ratios of Mothers' Produce.	·00—·05	·05—·15	·15—·25	·25—·35	·35—·45	·45—·55	·55—·65	·65—·75	·75—·85	·85—·95	·95—1·00	Totals
·00— ·05	—	—	—	—	—	—	—	—	—	—	—	—
·05— ·15	—	—	—	—	3	4	2	1·5	·5	—	—	11
·15— ·25	—	1	3	6	9	16·5	7·5	4	2	—	—	49
·25— ·35	1	2	7·5	14·5	33	28·5	24·5	20	7	2	—	140
·35— ·45	—	1	10·5	28·5	56	60	56	29·5	14·5	2	2	260
·45— ·55	—	2	13	33	58	76·5	68·5	20·5	16·5	3	—	291
·55— ·65	—	1	11	14	34	45	31	20	8	1	—	165
·65— ·75	—	—	2·5	8	10	23	12·5	6·5	4·5	—	—	67
·75— ·85	—	—	1	1·5	2	6	4·5	1	—	—	—	16
·85— ·95	—	—	—	—	—	—	1	—	—	—	—	1
·95—1·00	—	—	—	—	—	—	—	—	—	—	—	—
Totals	1	7	48·5	105·5	205	259·5	207·5	103	53	8	2	1000

TABLE II.

Correlation of Sex-Ratios of First Four Members of Mother and Daughter Mares' Produce. Thoroughbred Horses from The General Stud Book.

Sex-Ratio of First Four Members of Daughter's Produce.

Sex-Ratio of First Four Members of Mother's Produce.	$\frac{0}{4}$	$\frac{1}{4}$	$\frac{2}{4}$	$\frac{3}{4}$	$\frac{4}{4}$	Totals
$\frac{0}{4}$	3	12	35	20	10	80
$\frac{1}{4}$	20	65	119	72	15	291
$\frac{2}{4}$	19	104	137	97	23	380
$\frac{3}{4}$	8	45	84	63	13	213
$\frac{4}{4}$	1	8	17	10	—	36
Totals	51	234	392	262	61	1000

of sex-ratios derived from completed families of eight and upwards and from the first four members of these families respectively, while the means and standard deviations are given in Table III.

TABLE III.

Group		Mean	S. D.
Completed Families ...	Mother's Produce	·4620 ± ·0029	·1379 ± ·0021
	Daughter's Produce	·5020 ± ·0033	·1546 ± ·0023
First Four Members Only	Mother's Produce	·4585 ± ·0052	·2425 ± ·0037
	Daughter's Produce	·5012 ± ·0052	·2426 ± ·0037

In the completed family of the mother, at least one female must appear and this of course reduces the mean sex-ratio. When the offspring were not selected in this way, the mean sex-ratio was ·502. If we now apply the condition that at least one member is to be a female, the sex-ratio ought to become $\frac{n-1}{n}$ (·502) where n is the number in the family. The average family was found to be 11·433 and substituting this for n we get the sex-ratio to be ·458. Actually it was found to be ·462, an excellent agreement.

When the question of variability is considered we find as before that σ_x is zero. Taking the first four members of the family, the standard deviation is ·2426 ± ·0037, while that which would arise from a chance distribution in families of four is $\sqrt{\frac{\cdot 502 \times \cdot 498}{4}} = \cdot 2499$. The difference is within the probable error and it is to be noted that the actual S. D. is less than that which would arise from a chance distribution. According to Mr Cobb's suggestion, it ought to be greater.

If we consider completed families (only the 1000 cases in the second generation were taken) the theoretical variability is given by

$$N\sigma^2 = S\left[n_s\left(\bar{p} - \frac{m_s}{n_s}\right)^2 + pq\,\frac{n_s}{S}\right]$$

in the notation used by Prof. Pearson above, and from this formula σ was found to be ·1459, where the term depending on the means contributes practically nothing. Actually the standard deviation calculated from the grouped sex-ratios was found to be ·1546 ± ·0085, so that again the difference is within the limits of the probable error.

Turning now to the question of correlation, in the case of completed families of eight and upwards r was found to be ·0101 ± ·0213, while in the case of the first four members only, r was found to be − ·0064 ± ·0213. These coefficients are both zero within the limits of probable error so that no significant increase in correlation is obtained by raising the number of individuals on which the sex-ratio is based from 4 to an average of 11·4.

It should also be noted that Mr Cobb's corrective factor is *positive* and if the true correlation were at all comparable with its value found for other physical characters, which is of course always positive, the result of our calculation must give a positive correlation. The fact that it gives a small negative correlation is compatible with its being really zero but not with its being the reduced value of a true positive correlation found by using a positive reducing factor.

NOTICES AND BIBLIOGRAPHY.

NOTICES*.

Untersuchungen über das Verhältnis der Kopfmasse zu den Schädelmassen, by JAN CZEKANOWSKI. Braunschweig, 1907.

An interesting paper giving between 30 and 40 measurements, indices, etc., of each of 119 specimens (65 ♂ and 54 ♀) and the treatment of the observations. The calculations of the mean, median, average deviation, standard deviation, coefficient of variation and coefficient of correlation are explained. The method of moments is referred to, but the mth moment is given as $\sqrt[m]{\frac{1}{n}\sum_{\kappa=1}^{n} e_\kappa^m}$, where e_κ is the deviation and n the number of cases. An explanation of the measurements is given and various tables giving means etc. follow. Formulæ are given for the calculation of skull from head measurements. Amongst other interesting points the author refers to the variation of the thickness of the skin with the age of the individual at various parts of the head. Czekanowski does not appear to have read any of the very recent English statistical papers and he gives $\cdot 67449 \frac{1-r^2}{\sqrt{n}\,(1+r)}$ as the probable error of r, while in some of his correlations there is probably spurious correlation, e.g. the table on p. 28 which gives the correlation between the cephalic indices of the head and skull measurements.

Zur Frage der Correlationen der Muskelvarietäten, by JAN CZEKANOWSKI. New York, 1906 (Boas Memorial Volume).

Certain muscles are not always present, and this paper gives the frequency of the presence of thirteen muscles and the coefficients of correlation between the various muscles. The number of cases investigated is not large and the coefficients vary considerably. The subject would be well worth an extended investigation on the same lines.

The Numerical Proportions of the Sexes at Birth, by J. B. NICHOLS. American Anthropological Association, Lancaster, Pa. U.S.A. 1907.

Statistics from Europe, United States, South America, Australia, etc. are used, and the points dealt with are the proportions of births among living and still-born, among legitimate and illegitimate; multiple births; effect of war on sex ratios; differences between ratios in town and country and influence of sanitary environment. A valuable collection of statistics which would have been improved if an estimate of the probable errors had been given in each case.

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* Authors of memoirs who desire brief notices of their contents should forward offprints to this Journal, as it is often difficult to procure Journals in which the originals have been issued.

On the Theory of Correlation for any Number of Variables treated by a New System of Notation, by G. UDNY YULE. Proceedings of Royal Society, A, Vol. 79, 1907.

A restatement of the theory of correlation. Although the new system of notation does not appeal to one very favourably on a first reading, the results follow easily when the notation has been mastered.

Frequency Curves and Moments, by ROBERT HENDERSON. Journal of Institute of Actuaries, July, 1907.

A reprint of a paper which appeared recently in the Transactions of the Actuarial Society of America. It deals with the Sheppard adjustments and Pearson Type curves. The latter are re-numbered and the normal curve appears as Type I, and the Pearson Type III is called II. The paper suffers from the defects of giving in no case a reference to the original author or to a memoir whence the results are reproduced.

The Scope and Importance to the State of the Science of National Eugenics. The Fourteenth Boyle Lecture, by KARL PEARSON, F.R.S. London, Henry Frowde, 1907.

If the object of National Eugenics is to be attained it is necessary that the general public, or at least the leaders of public opinion, should appreciate its aims and the results of modern statistical work on heredity and kindred subjects. The general results of the work on eugenics and the practical conclusions to which they tend are dealt with forcibly and clearly in the Lecture, which should do much to awaken interest in the subject among thinking people. We earnestly hope that at no very distant date there will be the "strengthening of racial conscience" and the "scientific basis of conduct" for which Professor Pearson calls.

W. P. E.

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CONTENTS

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PAGE

I. The Probable Error of a Mean. (With Four Diagrams in the text.) By "Student" 1

II. Split-Hand and Split-Foot Deformities, their Types, Origin and Transmission. (With Plates I—VII and Two Diagrams in the text.) By THOMAS LEWIS, M.D., and DENNIS EMBLETON 26

III. On the Generalised Probable Error in Multiple Normal Correlation. (With Two Diagrams in the text.) By KARL PEARSON, F.R.S., and ALICE LEE, D.Sc. 59

IV. On Inheritance of the Deformity known as Split-Foot or Lobster-Claw. (With Plates VIII—XVI.) By KARL PEARSON, F.R.S. . . . 69

V. On a Determinantal Theory of Inheritance, from Notes and Suggestions by the late W. F. R. Weldon. By K. PEARSON . . . 80

Miscellanea. (i) Some Notes on Interpolation in n-dimension Space. (With Eight Diagrams in the text.) By W. PALIN ELDERTON 94

(ii) Note on the Relative Variability of the Sexes in *Carabus auratus*, L. By H. G. KRIBS 103

(iii) Variation in Flower-heads of *Gaillardia aristata*. (With Two Diagrams in the text.) By W. W. ROBBINS . . 106

(iv) The Effect of Errors of Observation upon the Correlation Coefficient. By J. A. COBB 109

(v) On Heredity in Sex. Remarks on Mr Cobb's Note. By KARL PEARSON, F.R.S. 109

(vi) On the Influence of Double Selection on the Variation and Correlation of two Characters. By KARL PEARSON, F.R.S. 111

(vii) On certain points concerning the Probable Error of the Standard Deviation. By RAYMOND PEARL 112

(viii) Addendum to Memoir: "Split-Hand and Split-Foot Deformities." By THOMAS LEWIS 117

(ix) On a Formula for Determining $\Gamma(x+1)$. EDITORIAL . 118

(x) On the Inheritance of the Sex-Ratio in the Thoroughbred Racehorse. By DAVID HERON 120

Notices and Bibliography 123

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IN CONSULTATION WITH FRANCIS GALTON
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VOLUME VI SEPTEMBER, 1908 NOS. 2 AND 3

PIGMENTATION SURVEY OF SCHOOL CHILDREN IN SCOTLAND.

COMMITTEE OF THE SURVEY.

Principal Sir **WILLIAM TURNER**, K.C.B., F.R.S., Chairman.
Professor **R. W. REID**, M.D., F.R.C.S.
J. GRAY, B.Sc.
J. F. TOCHER, B.Sc.

THE REPORT.

The accompanying Report which is published under the direction of the above Committee has been prepared by J. F. Tocher and consists of a Memoir on the reduced data and an Appendix. The memoir includes 72 tables, 19 diagrams and 78 maps. The Appendix contains 16 tables of classified data, and includes a list of teachers who made the Returns.

THE GRANTS.

Financial aid towards the Survey has to be acknowledged from the following sources:

			£	£
(1)	(α)	Grant by Royal Society in May 1902 .	200	
	(β)	„ „ „ 1904 .	100	
	(γ)	„ „ „ 1906 .	100	
		Total Grant by Royal Society . .	——	400
(2)		Grant by Carnegie Trust July 1908 . .		100
(3)		Donations by Lord Strathcona towards the payment of outlays on special sections of the work of analysis.		
(4)		The expense of printing the Appendix has been defrayed from a fund presented to this Journal in memory of W. F. R. Weldon.		

PIGMENTATION SURVEY OF SCHOOL CHILDREN IN SCOTLAND*.

By J. F. TOCHER, B.Sc.

CONTENTS.

MEMOIR.

Section — Page
1. Introductory 131
2. Arrangements prior to Organization 132
3. Organization and Carrying out of the Survey 136
4. Problems to be discussed . . 141
5. Statistical Methods employed to determine Significant Differences 143
6. Relative Local Differences geographically considered. Individual Differences in each Class 146
   I. Explanatory and Introductory 146
   II. Differences in Hair Colour: (*α*) Fair Hair; (*β*) Red Hair; (*γ*) Medium Hair; (*δ*) Dark Hair; (*ε*) Jet Black Hair . 150
   III. Differences in Eye Colour: (*α*) Blue Eyes; (*β*) Light Eyes; (*γ*) Medium Eyes; (*δ*) Dark Eyes . . . 157
7. The General Resemblance of Local Populations to the General Population 162
   I. Introductory 162
   II. Hair Colour: (*α*) Divisions; (*β*) Counties; (*γ*) Districts . 165
   III. Eye Colour: (*α*) Divisions; (*β*) Counties; (*γ*) Districts . 172
8. Class Segregation 175
   I. Interlocal Constants . . 175
   II. Significance of the Constants . 176
9. Peculiarities in the Distribution of Colour in Scotland . . 179
   I. General 179
   II. Red Hair 181
   III. Relationship between Gaelic speaking Population and Pigmentation 182
   IV. Relationships between Pigmentation, Density of Population, and Foreigners . . . 185
   V. Relationship between Pigmentation and the Death Rate . 187
   VI. The Probable Cause of the Association of the Medium or Brownhaired Class with Density of Population . 188
   VII. Colour Classes which are associated geographically . 194
   VIII. Relationships between Pigmentation and Physical and Mental Defects . . . 197
10. Degree of Resemblance between the Boy and Girl Population in each of the Colour Classes . 198
11. The Colour Characteristics of the Population of Greater Glasgow and Environs 200
   I. Introductory, with Tables of classified data . . . 200

---

* An Appendix containing the actual data is issued as a supplement to this volume of *Biometrika*.

Section Page
II. Analysis of Glasgow Data . 203
 (α) General Divergency in Colour 203
 (1) Hair Colour; (2) Eye Colour 203
 (β) Individual Classes. . 207
 (1) Hair Colour; (2) Eye Colour 207
 (γ) General View . . 208
III. Specific Elements in the Glasgow Population causing Divergency 210
 (α) Introductory; (β) Gaelic speaking Population of Glasgow; (γ) the Foreign Population of Glasgow; (δ) the Irish Population of Glasgow 210
IV. Summary of Results of the Analysis of the Population of Glasgow 217
12. Comparison with other Data . 219
 I. Scottish Data: (α) East Aberdeenshire Children, 1896; (β) Scottish Adults; the Insane; (γ) Scottish Adults, Beddoe's observations . 219
 II. Foreign Data: (α) the Actual Data; (β) Comments . . 221
 III. The Data bearing on Correlation and comparison with similar Data . . . 223
 (α) General; (β) Comparisons 223
13. Summary of Results . . . 225

(1) *Introductory.*

In 1896, the writer organized and carried out a survey of the colour characters of the school population (14,561) of East Aberdeenshire*—the first local survey of its kind in the British Isles. The cooperation of the teachers in East Aberdeenshire was so hearty that the writer conceived the idea of making a survey of the colour characters of the whole of the school population of Scotland and, afterwards, of making a survey of the physical characters of the Scottish adult population. The chief obstacle in the way of carrying out both schemes was the want of funds. At Glasgow, for instance, the British Association approved of the idea but made no Grant†. In December, 1901, however, the writer applied to the Royal Society of London for a Grant of £200, naming a Scottish Committee prepared to see the pigmentation survey carried out. The promotion of the adult survey was meantime held in abeyance. The committee named was constituted and consisted of the following: Professor, now Principal Sir William Turner, K.C.B., F.R.S., chairman; Professor R. W. Reid, M.D., F.R.C.S.; J. Gray, B.Sc., and the writer. Under the direction of this committee, the Survey was made and this Report is published. The Grant applied for was given in May 1902, and the supplementary Grants of £100 each were given in 1904 and 1906. The Royal Society has thus supplied the sum of £400 to enable the Survey to be carried out and to further the statistical portion of the work. A Donation from Lord Strathcona in November 1906 of £100 towards anthropological research on adults and children in Scotland has also to be gratefully acknowledged. A portion (£21. 10*s.*) has been expended on the work of the present Survey. The Carnegie Trust in July 1908 made a Grant of £100 in aid of publication. The total Grants in aid up to the present date thus amount to £521. 10*s.* The total cost of the Survey including outlays, for aid in statistical, clerical and other work has been £860. 1*s.* 4*d.* The writer desires gratefully to acknowledge all the Grants made, and further the aid given by Sir William Turner and Professor Reid towards securing them. Without these Grants, the Survey would not have been made.

---

* Tocher, "Ethnographical Survey of School Children in Buchan," *Trans. Buchan Field Club*, Vol. IV. pp. 137—152. Observations on the colour characters of over 2800 adults belonging to the same population had already been made by the writer and his assistants in 1895 at Mintlaw in Aberdeenshire. The results of an elementary analysis of these observations together with the results of a similar analysis of measurements of adults in various parts of Aberdeenshire are embodied in joint papers by J. Gray and the writer published in the following Journals:—*Jour. Anthrop. Inst.* Vol. XXX. 1900, pp. 104—124; *B. A. Report*, 1900, pp. 193—195; *B. A. Report*, 1904, p. 707; etc.

† A Committee was formed, but no work was done, and it was dissolved in 1903, on its being pointed out that a Scottish committee with a Grant from the Royal Society was carrying out the survey.

(2) *Arrangements prior to organization.*

Immediately on receiving the Royal Society Grant of £200 in May, 1902, the writer placed himself in communication with the officials of the Educational Institute of Scotland and other teachers throughout the country. The teachers were found to be distinctly sympathetic and interested in the scheme and, by the end of December, the writer was able to report to the Committee that there was every likelihood of the teachers consenting to make the necessary observations. On the 27th December, the General Committee of Management of the Educational Institute of Scotland passed a favourable resolution communicated to the author by the secretary of the Institute in the following terms:—

COATBRIDGE, 27*th Dec.* 1902.

DEAR SIR,

I have pleasure in informing you that the General Committee of Management at their meeting to-day adopted the following motion :—"That the General Committee of Management recommend the members of the Institute to afford whatever support it may be in their power to give towards the carrying out of a pigmentation survey of school children in Scotland."

Faithfully yours,
(Signed) JOHN LAURENCE,
Sec. of the Institute.

J. F. Tocher, Esq.
Peterhead.

Thus the cooperation of the teaching profession seemed assured and every confidence was felt that the returns would be made by the teachers without any delay, after receiving the necessary schedules and instructions.

The preparation of the schedules and instructions caused the Committee much anxiety. Quite 18 months were spent in discussing the best way to have the observations made. All the leading authorities were consulted as to the numbers of categories to be employed, the reproduction of suitable colour cards, and other means of aiding the teachers in their task of determining the precise colours involved. Although in many respects desirable, the limits of this memoir preclude the author from giving more than a general statement of the decision arrived at. At the outset both Sir William Turner and Professor Reid agreed that it would be most desirable to have either standard specimens of hair and artificial eyes properly shaded or to have colour cards if such were possible. Dr Francis Galton, Dr A. C. Haddon, Professors Macalister, K. Pearson and D. J. Cunningham were each consulted and gave valuable suggestions. Artists and lithographers were employed to reproduce the shades of colour from a very complete set of specimens of hair of all shades and from specially prepared artificial eyes. A good deal of progress was made, but on attempting to determine the various classes by aid of colour cards giving either the limits or the means of the classes, the method failed to produce satisfactory results. It was found that, compared with the results obtained by the use of samples of natural hair, observers differed seriously in the classification of colour by this method. This appeared to be due to the comparative failure of the lithographers to reproduce the natural shades required. The writer devised the following analytical table (Table I.), the range of each class being

TABLE I.

Analytical Table for Hair Colours.

<table>
<tr><td rowspan="3">RED
The hair is red ; either light red, bright red, or dark red
——
All colours which approach more to red than to brown or flaxen
——
CLASS 1.</td><td colspan="3">NOT RED
The hair is not red. It is either fair, brown, or dark</td></tr>
<tr><td rowspan="2">FAIR
The hair is fair, that is white, flaxen, or golden-yellow only
——
{A VERY LIGHT brown may be included here}
——
CLASS 2.</td><td colspan="2">NOT FAIR
The hair is not fair. It is brown (medium) or dark</td></tr>
<tr><td>MEDIUM
The hair is chestnut brown, brownish, or is neither red, fair, nor dark
——
CLASS 3.</td><td>DARK
The hair is dark brown, or dark or black, but not jet black
CLASS 4.
——
JET BLACK ONLY
CLASS 5.</td></tr>
</table>

NOTE.—There are five divisions of hair colours recognised by the Committee.

No. 1.—The first includes all shades of red—light red, bright red, and sandy red, &c.

No. 2.—The second division includes all shades of fair, but great care must be taken *not* to include brown or medium hair. Flaxen, white, and golden yellow are the shades of fair recognised.

No. 3.—The third division includes chestnut brown, dull brown, and all shades, *not red fair, or dark.*

No. 4.—The fourth division, dark, includes very dark brown (looking black at a moderate distance), and black.

No. 5.—The fifth division is very uncommon. It is jet black

TABLE I.—(*continued*).

Analytical Table for Eye Colours.

<table>
<tr><td>PURE BLUE
The eyes are pure blue</td><td colspan="3">NOT PURE BLUE
The eyes are not pure blue. They are either brown, grey, very light blue, or mixed</td></tr>
<tr><td rowspan="2">Deep blue or pure blue is CLASS 1.
——
Light blue is CLASS 2.</td><td rowspan="2">DARK
The eyes are hazel brown, dark brown, or simply dark
——
CLASS 4.</td><td colspan="2">NOT DARK
The eyes are not brown. They are either grey or mixed.
The grey eyes may be either very light blue, light grey, or simply grey. Light grey eyes belong to Class 2, while grey and mixed belong to Class 3</td></tr>
<tr><td>LIGHT
The eyes are light grey, very light blue, or bluish grey.
——
CLASS 2.</td><td>MEDIUM
The eyes are neither light grey, very light blue, nor bluish grey, but are either grey, greenish, orange, VERY light hazel, or mixed. They belong to CLASS 3.</td></tr>
</table>

NOTE.—There are four classes or divisions of eyes.

No. 1.—The first is the pure blue or deep blue eye which cannot be mistaken.

No. 2.—The second includes light blue and light grey eyes.

No. 3.—The third includes all eyes not blue, light grey, or brown—they are called medium eyes, and include grey, green, orange, and other mixed shades.

No. 4.—The fourth class includes hazel brown, dark brown, and dark eyes generally. The fourth class is usually spoken of as dark, and the colour appears homogeneous in character at a distance of two feet, at which distance observations ought to be made.

In noting the colour of the eyes, first note whether they are blue or brown. If these are excluded note whether they are grey. If light grey, they are light eyes, if grey, they are medium eyes. If the eyes are neither blue (1), grey (3), nor brown (4) they are either light eyes (2) or medium eyes (3) [of which grey, previously mentioned, is only one shade]. Light eyes having been already excluded, they are medium or mixed eyes. *It is best to call up a few children at a time and judge by comparison.*

fully described. In making colour observations, each class in this table is determinable by the observer by a process of elimination of the other classes. The results obtained by the use of this table were now compared with the results obtained by using samples of hair, for hair colour, and of glass eyes, for eye colour and also with the results, for eye colour, obtained from observations on boys and girls selected as types of each class. It was found that both sets of figures closely agreed, and the results were therefore considered very satisfactory. The colour card method

Table II.

Pigmentation Survey of School Children in Scotland.

Name of School .... *Parish* .... *County* .... *District No.* ....

Name of Teacher .... *Date of Survey*

Sex of List of Children on this Sheet, ...

(Boys or Girls).

*** *To save trouble to yourself, number the whole school consecutively from 1 onwards, after the names have been entered from Register and before noting the colours.*

INDICATE COLOUR OF HAIR AND EYES by an X in Corresponding Column

No.	AGE.	HAIR.					EYES				SURNAME.	RELATIONSHIPS.
		Fair	Red	Med	Dark	Jet Black	Pure Blue	Light	Med	Dark		Use this column to indicate relationships in any manner you please if you do not use the next column. If you use the next column, ignore this one.

RELATIONSHIPS.

Indicate relationships by grouping and bracketing the numbers of the children who are related to one another in the undernoted divisions, which state the relationships.

For example, if 7 and 11 are *full* brothers, sisters, or sister and brother, write in "Full Brothers and Sisters" column in brackets, thus, the figures (7-11).

If 10 and 23 are cousins by fathers being *full* brothers, write (10-23),

&c., &c.

FULL BROTHERS AND SISTERS.

No.	and No.
,,	,,
,,	,,
,,	,,
,,	,,
,,	,,
,,	,,
,,	,,
,,	,,
,,	,,

COUSINS.

Children whose fathers are *full* brothers (record and bracket the numbers here).		Children whose mothers are *full* sisters (record and bracket the numbers here).	
Nos.	and	Nos.	and
,,	,,	,,	,,
,,	,,	,,	,,
,,	,,	,,	,,
,,	,,	,,	,,
,,	,,	,,	,,
,,	,,	,,	,,
,,	,,	,,	,,
,,	,,	,,	,,
,,	,,	,,	,,
,,	,,	,,	,,
,,	,,	,,	,,
,,	,,	,,	,,
,,	,,	,,	,,

Children whose fathers on the one hand and children whose mothers on the other are *full* brothers and sisters.

No.—'s Father and No.—'s Mother.
,, ,, and ,, ,,
,, ,, and ,, ,,
,, ,, and ,, ,,
,, ,, and ,, ,,
,, ,, and ,, ,,
,, ,, and ,, ,,
,, ,, and ,, ,,
,, ,, and ,, ,,

was then reluctantly abandoned and the analytical table with broad classes was adopted as one likely to lead to the least error in determining the colour characters of the children. The accompanying schedule (Table II., much reduced size) was adopted by the Committee, the table (Table I.) with the description of the classes being printed on the back of each schedule.

The form of schedule and descriptive analytical table being definitely settled the author drew up a circular letter to the teachers which was adopted by the Committee*.

Mr John Gray's name was, with the consent of the Committee, associated with the writer's in the circular, as it had been mutually arranged that, after the data had been collected and summarised by the author, a joint paper should be prepared. This idea was departed from, at a later date, at Mr Gray's suggestion. With the Committee's approval he has, instead, written a short memoir illustrating his method of dealing with the observations grouped into districts, from Tables XI., XII., XIII. and XIV. of Appendix supplied to him by the writer who, on completing the statistical analysis, gladly supplied Mr Gray with the tables referred to†. District grouping suited the purpose he had in view of representing, by contour lines, the imaginary up and down steps by which he assumes one locality gradually to merge in intensity of colour into adjacent ones. The

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7 *December* 1903.

*DEAR SIR, OR MADAM,

As you may have seen reported, this Committee proposes, with your kind assistance, to carry out a survey of the colour characteristics of the school children of Scotland.

We beg to enclose the necessary form, and we should feel very much obliged if you will kindly record the names and colour characteristics of the children of your school for the use of the above Committee.

The purpose of this survey of the colour characteristics of the children is to collect statistics in order to elucidate racial characters, the laws of heredity, and the general problem of evolution.

The Committee suggests that, when convenient, the teacher in charge of each class should first have the names and ages, and if possible the relationships, of the children recorded in the sheets. After this has been completed, he or she could then, at convenient times, call up the children, five or six at a time, and note the colour of the hair and the colour of the eyes, following the instructions on the analytical table on the back of each observation sheet.

We may briefly mention that in carrying out this Survey, besides the private goodwill of hundreds of Teachers, the General Committee of Management of the Educational Institute of Scotland support the idea. The following resolution of the General Committee was adopted in December last:—

> "That the G.C.M. recommend the Members of the Institute to afford whatever support it may be in their power to give towards the carrying out of a Pigmentation Survey of School Children in Scotland."

The Royal Society is aiding the survey by a grant from the Government Funds, while the results, besides being published in scientific journals, will be printed as a separate memoir. This memoir will contain a complete list of the contributing teachers and of the statistics forwarded from each school. We have provided for the survey of over 750,000 children, which is the estimated number in Scotland.

We sincerely trust you will, without inconvenience to yourself, supply the Committee early with the particulars asked, and do what you have in your power to assist in a survey which has such a high bearing on the racial characters of the Scottish people.

† These tables as supplied to Mr Gray do not, of course, contain the figures from the late Returns.

reader is referred to Mr Gray's paper for details as to this system of representation of intensity of colour. The author has to acknowledge his indebtedness to Mr Gray for the help he gave in the construction of the schedule and to thank him cordially for such cooperation as he was able to give otherwise. Owing to his residence in London, Mr Gray was unable to take part either in the actual work of organizing and carrying out of the survey, or in the laborious and prolonged statistical analysis after the survey had been completed. The writer, however, received great assistance from his own clerical staff, the members of which worked frequently at high pressure to a late hour, in order to have the work completed within a reasonable limit of time.

(3) *Organization and carrying out of the Survey.*

The colour classes, schedules and other forms being approved of by the Committee, the next step to be considered was their issue to the teachers. A reference to the Appendix to the Annual Report* issued by the Scotch Education Department showed that in 1902 there were 3145 schools in the 33 counties of Scotland with an actual average attendance of 646,501 scholars. It was further noted, that, including principals, there were 11,638 certificated teachers giving instruction to these children, and who, on the suggestion of the principals, might be willing to take part in the voluntary task of noting the colour characters of the children and recording them, together with the other information desired, on the forms supplied. It was recognised from the outset that while many principals would be quite willing to survey the whole school in each case, this would be a task of great magnitude in the larger schools, where the average attendance reached several hundreds and in many cases considerably over a thousand. The average number to be examined in each school, on the assumption that each head master or mistress made the observations, amounted to 205 children; while if every certificated teacher took part, the number was reduced to 55. It was seen that there would be great deviations in excess of these averages and therefore it was considered eminently advisable, if the survey was to be a success, that the certificated teachers generally should be invited to take part. This, it will be seen presently, was done through the medium of the principals, with the most fruitful results from both principal and class teacher. The schools from which it was considered desirable to receive returns of observations on the colour characters of the children, were those aided by Parliamentary Grants. The complete list of these schools receiving such grants for the twelve months ending the 31st August, 1902, is given in the Appendix to the Report already referred to, and this list formed the basis of the author's operations in carrying out the survey. As was originally the design of the author, he arranged to classify the returns in the usual and well-known basis of parishes and counties, and also into groups intermediate on an average in magnitude between parishes and counties. As will

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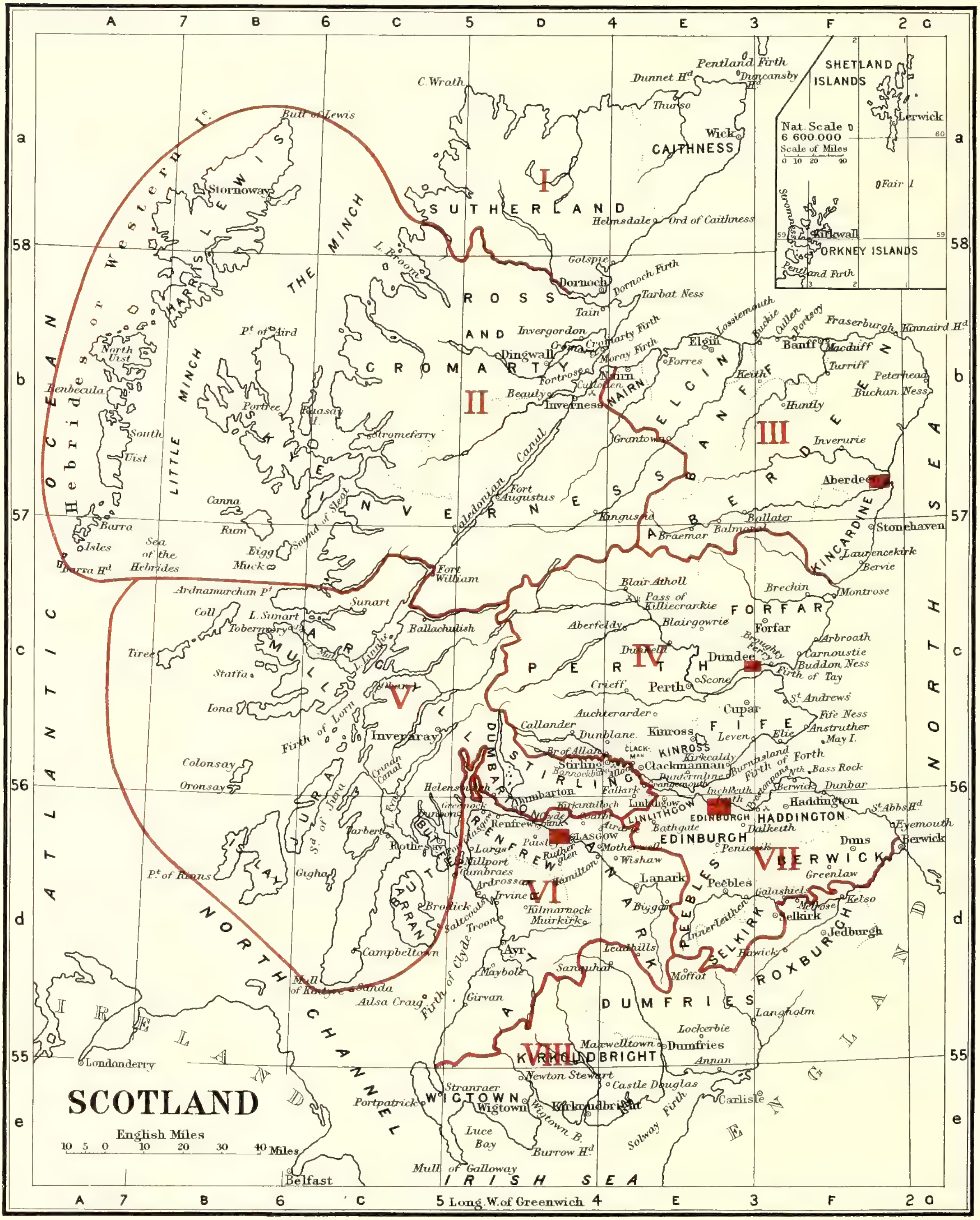
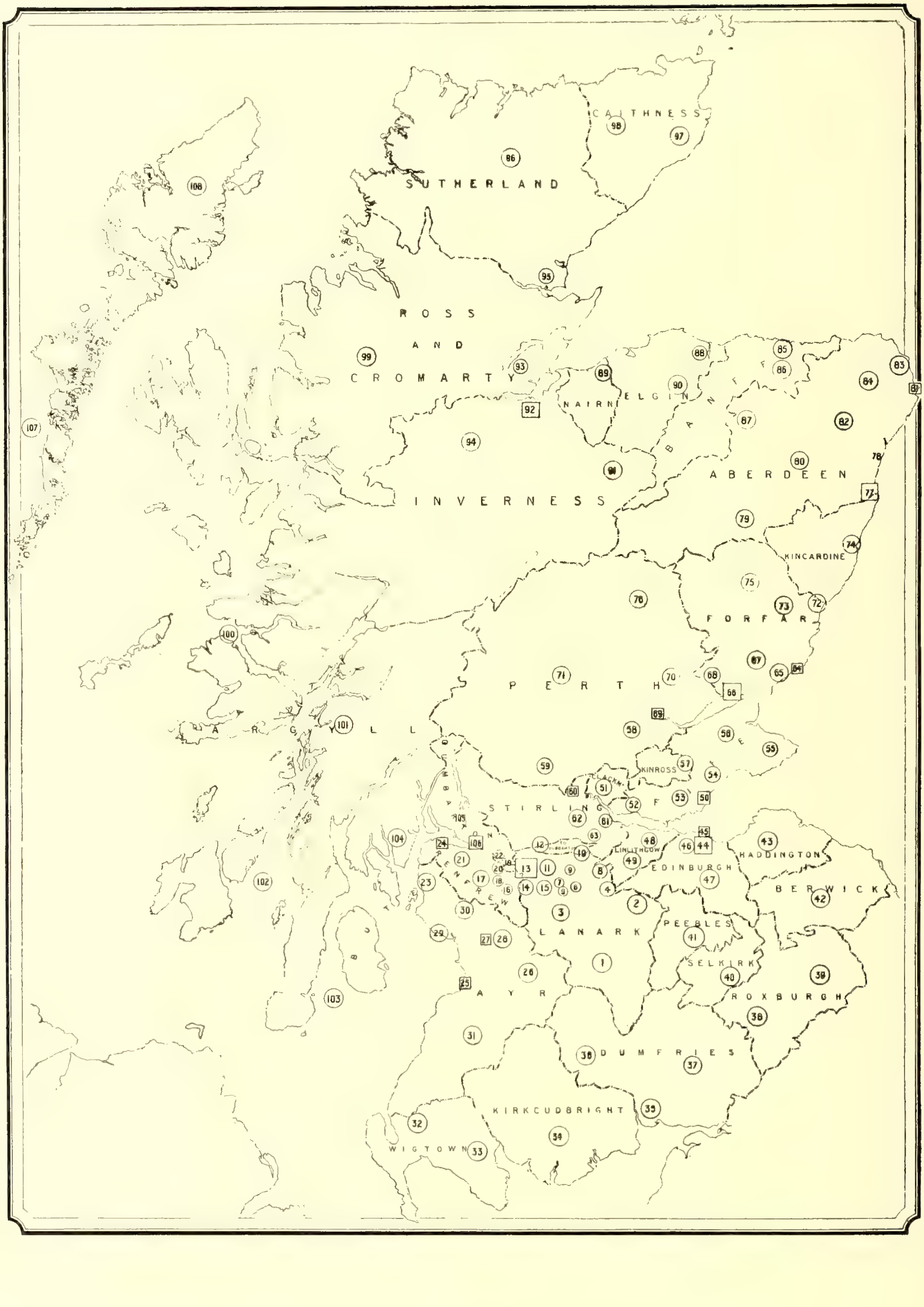
* Report of the Committee of Council on Education in Scotland, with Appendix, 1902—1903. Appendix, Part II. Table 3, pp. 488—651.

Plate I.


SCOTLAND
English Miles
10 5 0 10 20 30 40 Miles
5 Long. W. of Greenwich 4
A 7 B 6 C 5 D 4 E 3 F 2 G
a b c d e
58 57 56 55
I
II
III
IV
V
VI
VII
VIII
SHETLAND ISLANDS
Lerwick
Fair I.
Nat. Scale 6 600 000
Scale of Miles
0 10 20 40
Kirkwall
ORKNEY ISLANDS
Stromness
Pentland Firth
C. Wrath
Dunnet Hd
Duncansby Hd
Thurso
Wick
CAITHNESS
SUTHERLAND
Helmsdale
Ord of Caithness
Golspie
Dornoch
Dornoch Firth
Tarbat Ness
Tain
Butt of Lewis
Stornoway
LEWIS
HARRIS
Western Is.
Hebrides or
North Uist
South Uist
Benbecula
Barra
Barra Hd
Isles
THE MINCH
LITTLE MINCH
L. Broom
Pt of Aird
ROSS AND CROMARTY
Invergordon
Cromarty
Cromarty Firth
Dingwall
Moray Firth
Fortrose
Beauly
Inverness
Nairn
NAIRN
Culloden
Lossiemouth
Elgin
Forres
ELGIN
Buckie
Cullen
Portsoy
Banff
Macduff
Fraserburgh
Kinnaird Hd
Turriff
Keith
BANFF
Peterhead
Buchan Ness
Huntly
Inverurie
ABERDEEN
Aberdeen
Grantown
Portree
SKYE
Raasay I.
Stromeferry
INVERNESS
Caledonian Canal
Fort Augustus
Kingussie
Braemar
Balmoral
Ballater
Canna
Rum
Eigg
Muck
Sound of Sleat
Sea of the Hebrides
Fort William
Ardnamurchan Pt
Sunart
Coll
L. Sunart
Tobermory
Tiree
MULL
Staffa
Iona
ARGYLL
Ballachulish
L. Linnhe
Oban
Firth of Lorn
Inveraray
Crinan Canal
Colonsay
Oronsay
JURA
Sd. of Jura
ISLAY
Pt of Rinns
Gigha
Tarbert
L. Fyne
KINTYRE
Campbeltown
Mull of Kintyre
Sanda
NORTH CHANNEL
ATLANTIC OCEAN
KINCARDINE
Stonehaven
Laurencekirk
Bervie
Montrose
Brechin
Blair Atholl
Pass of Killiecrankie
FORFAR
Forfar
Blairgowrie
Aberfeldy
Dunkeld
PERTH
Perth
Scone
Dundee
Broughty Ferry
Arbroath
Carnoustie
Buddon Ness
Firth of Tay
St Andrews
Cupar
FIFE
Fife Ness
Elie
Leven
Anstruther
May I.
Crieff
Auchterarder
Callander
Dunblane
Kinross
KINROSS
Br. of Allan
Stirling
Bannockburn
STIRLING
CLACKMANNAN
Clackmannan
Alloa
Kirkcaldy
Dunfermline
Burntisland
Firth of Forth
Grangemouth
Falkirk
Inchkeith
Prestonpans
N. Berwick
Bass Rock
Dunbar
Haddington
HADDINGTON
St Abbs Hd
Eyemouth
Berwick
Duns
BERWICK
Greenlaw
Linlithgow
LINLITHGOW
Leith
EDINBURGH
Edinburgh
Dalkeith
Penicuik
Bathgate
Airdrie
DUMBARTON
Dumbarton
Helensburgh
Greenock
Kirkintilloch
Coatbridge
Clydebank
Renfrew
Paisley
Glasgow
Rutherglen
RENFREW
Motherwell
Wishaw
Hamilton
LANARK
Lanark
Biggar
Dunoon
BUTE
Rothesay
Largs
Millport
Cumbraes
Ardrossan
Irvine
Kilmarnock
Muirkirk
ARRAN
Brodick
Saltcoats
Troon
Ayr
AYR
Maybole
Girvan
Ailsa Craig
Firth of Clyde
Sanquhar
Leadhills
PEEBLES
Peebles
Innerleithen
Galashiels
Melrose
Selkirk
SELKIRK
Kelso
Jedburgh
Hawick
ROXBURGH
Moffat
DUMFRIES
Langholm
Lockerbie
Dumfries
Annan
Maxwelltown
KIRKCUDBRIGHT
Newton Stewart
Castle Douglas
Kirkcudbright
Stranraer
Portpatrick
WIGTOWN
Wigtown
Wigtown B.
Luce Bay
Burrow Hd
Mull of Galloway
Solway Firth
Carlisle
IRISH SEA
Londonderry
Belfast
IRELAND
ENGLAND
NORTH SEA

W & A.K. Johnston Limited, Edinburgh & London.


CAITHNESS
98
97
SUTHERLAND
86
95
ROSS AND CROMARTY
99
93
92
NAIRN
89
ELGIN
90
BANFF
88
85
86
87
83
84
81
82
78
ABERDEEN
80
77
79
INVERNESS
94
91
108
107
KINCARDINE
74
75
72
73
FORFAR
67
65
64
68
66
70
71
PERTH
69
58
56
55
59
100
ARGYLL
101
DUMBARTON
105
104
24
106
KINROSS
57
54
CLACKM.
51
60
STIRLING
52
FIFE
53
50
62
61
63
12
TO DUMBARTON
10
48
LINLITHGOW
49
45
46
44
HADDINGTON
43
EDINBURGH
47
8
4
2
RENFREW
21
22
20
19
13
11
9
17
18
16
14
15
7
6
23
30
3
LANARK
1
102
BUTE
29
27
28
26
25
AYR
103
31
PEEBLES
41
SELKIRK
40
BERWICK
42
39
ROXBURGH
38
36
DUMFRIES
37
35
KIRKCUDBRIGHT
34
32
WIGTOWN
33

be seen later, these two methods were adopted by the Committee and employed by the author as convenient and desirable ones for the purpose of analysis. At this stage, however, Mr John Gray suggested "the natural subdivision of the country into river basins, as it is well known that watersheds, when they form mountain ranges even of moderate size act as racial barriers." The view was expressed by him that "if the ordinary subdivision into counties were adopted, we should have in many cases to include populations with quite different characteristics in the same division and valuable ethnic distinctions would be lost in taking an average." The suggestion seemed a good one as a means of determining the differences between the populations in the various river basins. Also, when the population in each river basin is subdivided into districts, we have the means of determining whether any one district significantly differs from another in that basin. But this method of grouping is neither superior nor inferior to any other method of grouping populations in adjacent areas, as all that can be said in each case is that, conformably to size of sample, the population differs or does not differ from another population or from the general population of the country. Thus counties and groups of counties are quite convenient groups for the statistician to deal with, and since this method of grouping is well known to the public, it has a slight advantage over any other. Again, one must remember that no one method of grouping will solve all the problems the anthropometrician desires to solve. For instance, one may wish to contrast a city population with its environs; a mining population with a rural one; or a coast population with an adjacent inland population. Thus special groupings are frequently necessary.

In a small country like Scotland the river basins are exceedingly small, compared with the great basins on the continents of Europe, Asia, Africa and America. Besides, one has in Scotland a population the vast majority of the members of which speak one language and which has bred intraracially for generations. It therefore did not seem to the writer to be likely that grouping by river basins alone would yield all the information obtainable as to the distribution of colour, but the general idea of basins was kept in view in constituting the groups intermediate between parishes and counties, namely, districts. Thus a satisfactory solution of the area problem was found, since all the groupings discussed, namely schools, parishes, districts, counties and river basins, were and are available for statistical analysis.

The writer proceeded to carry out the district* system of grouping, commencing with the county of Lanark. Altogether 110 districts were thus constituted, the task of locating schools on the maps being an exceedingly laborious one indeed, so that much time was consumed in the construction of the districts. The Key maps opposite page 137 (Maps I.† and II.) show in a general way the location of these districts, while their exact relationship to counties is given in the following table (Table III.).

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* The special district grouping has been used by the writer to determine urban, suburban and rural differences and, as already stated, is the basis of Mr Gray's memoir. Of course the maps constructed by him show the districts graded and do not show the actual numerical district averages as given in tables supplied to him.

† For names of the Divisions see Explanatory Note, p. 148.

TABLE III.

Counties (with Districts).

Aberdeen, 77, 78, 79, 80, 81, 82, 83, 84, 86, 87. Argyll, 100, 101, 102, 103, 104. Ayr, 23, 25, 26, 27, 28, 29, 30, 31, 32, 33, 36. Banff, 85, 86, 87, 90, 91. Berwick, 39, 42. Bute, 103, 104. Caithness, 97, 98. Clackmannan, 51. Dumbarton, 10, 12, 19, 22, 101, 105, 106. Dumfries, 35, 36, 37. Edinburgh, 44, 45, 46, 47. Elgin, 88, 89, 90, 91. Fife, 50, 52, 53, 54, 55, 56, 57. Forfar, 64, 65, 66, 67, 68, 72, 73, 75, 76. Haddington, 43. Inverness, 89, 91, 92, 93, 94, 99, 100, 107, 108. Kincardine, 72, 73, 74, 75, 79. Kinross, 57. Kirkcudbright, 33, 34, 36. Lanark, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15. Linlithgow, 48, 49. Orkney, 109, 110. Nairn, 89, 90. Peebles, 41. Perth, 51, 57, 58, 59, 68, 69, 70, 71, 76. Renfrew, 14, 16, 17, 18, 19, 20, 21, 23, 24. Ross and Cromarty, 93, 95, 96, 99, 108. Roxburgh, 37, 38, 39. Selkirk, 38, 40. Shetland, 110. Stirling, 10, 12, 59, 60, 61, 62, 63. Sutherland, 95, 96. Wigtown, 32, 33.

This completed the work of organization, and the writer at once proceeded to carry out the survey. On the afternoon of the 7th December, 1903, the schedules, with instructions, leaflets stating fully the object of the survey, circular letters to teachers and addressed return envelopes* were sent out from Peterhead to 3329† different school establishments in Scotland. At the same time an explanatory letter, setting out the objects of the survey, and the nature of the results expected to flow from the data about to be collected, was sent to all the leading daily and weekly newspapers in the country. Public attention was thus at once directed to the scheme approved of and circulated by a Committee which had for two of its members Professor (now Principal) Sir Wm. Turner, and Professor R. W. Reid, well known University teachers, and notable for their contributions in the domain of anatomical and anthropological science. The fact of having two such experienced and distinguished men associated with the survey, actively promoting it and directly recommending it to the teachers, has meant everything to the success of the undertaking, and has translated it from a desirable and important scheme on paper to an accomplished fact. The author can never sufficiently thank Sir Wm. Turner and Professor Reid for their solid backing of the survey, their hearty cooperation during the entire period from its inception until now, and for their uniform courtesy and kindness during the entire course of the many interviews the author has had with each. The proposed survey was widely noticed by the daily press, was favourably commented on and strongly recommended to the notice of the teachers.

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* These envelopes were addressed to 36, York Place, Edinburgh, when by arrangement with the Post Office, they were, as received, immediately sent on to Peterhead. The writer's examining work took him frequently to Edinburgh and permitted of this arrangement being carried out. On his own behalf and that of the Committee he has cordially to thank Mr J. Rutherford Hill and his staff for providing a collecting centre for the Returns and for the trouble and care taken in sending them on to their present resting place.

† This was the apparent number of schools at the time. Several of these were afterwards found to be merged in other schools while a few were found to be extinct.

Meantime, in order to have the returns systematically arranged for inspection and tabling, two large cases (9′ × 7′) having 120 compartments were made ready and put in the writer's laboratory. Of the compartments, 110 were prepared for the special reception of the returns by districts, but of course each return envelope had printed and written on it the name of the school, parish, district and county to which it referred, for immediate identification. The remaining compartments were reserved for incomplete returns. A special case with county compartments was prepared to deal with the separate correspondence and a series of despatch boxes was obtained to hold and systematise the tabled data. These, with a typewriter, constituted the equipment for the survey. Everything was now ready for action.

On the 8th December, one day after the issue of the schedules, the first group of returns—5 in number—was received. After this a steady flow of returns came by each post. Within a fortnight, 366 had been received, and by the beginning of the last week of December the author was able to submit his first Interim Report to the Royal Society, stating that over 700 had been returned. Hundreds of letters had meantime been received asking for additional schedules and for explanation as to what appeared doubtful to the teachers making enquiries. These were all promptly answered, and as a result of the experience gained with those returns already sent in, an additional explanatory circular was sent out to those schools from which returns had not yet been made. This circular made clear doubtful points with regard to (1) classification of boys and girls, and (2) the method of recording relationships. The circular had the desired effect of obviating any further difficulties in making the observations. A steady stream of returns came during the early months of the year 1904. Each return was at once acknowledged and the teacher making the return thanked on behalf of the Committee. The response of the teachers was remarkable. The vast majority of them made the returns in an evidently painstaking and careful manner; and a great many of them, besides, wrote explanatory letters as to relationships, ancestry and probable racial mixture of their groups. The author was kept employed acknowledging these, and in replying to the hundreds of additional letters of enquiry during the first nine months of the year. In order to keep the scheme fully before the teachers, a reminder circular was issued in April to those schools from which no returns or acknowledgments had been received. This had the effect of bringing in a larger proportion of returns during the month of April. The rate steadily decreased until November, when only 3—the last included in the analysis—came in by post and were acknowledged. The following table (Table IV.) shows the actual numbers received during each month and the rate of return per cent. per month.

Altogether, 2695 returns were however received, but of these 407 were incomplete in certain particulars. Over 500 schools therefore made no return. The following table shows only the number of schools from which complete returns were received. With regard to the incomplete ones, either the names, ages, sex or

TABLE IV.

Table of Returns Received.

Year	Month	Number received	Per cent.
1903	December	817	35·71
1904	January	548	23·95
,,	February	344	15·04
,,	March	146	6·38
,,	April	270	11·80
,,	May	84	3·67
,,	June	22	·96
,,	July	22	·96
,,	August	25	1·09
,,	September	5	·22
,,	October	2	·09
,,	November	3	·13
Totals	—	2288	100·00

colour characters singly or jointly with one another were wanting. These schools have not been dealt with in this memoir. The data proper therefore consisted of fully complete returns from 2288 schools containing the records of the names, ages, sex, fraternal and cousin relationships, and colour characters of 257,766 boys and 244,389 girls, a total of 502,155 children. Although there was a good deal of further correspondence with the teachers, only a few more returns were received after November, 1904. These have not been included in the district analysis which was in operation before the returns were received but have been included in the division, county and general analyses*. The work of classification and tabling, which was commenced as soon as practicable, was soon in full operation. The response of the teachers had been remarkably enthusiastic and complete. The survey was an accomplished fact.

On behalf of the Committee the writer begs to acknowledge its great obligations to the teaching profession in Scotland for so promptly responding to the invitation of the Committee to carry out the desired observations. The writer also wishes to record his *personal* sense of indebtedness to the teachers and to thank them very cordially for all the pains and trouble they have taken in making the elaborate returns so vital to the success of the scheme. The credit of the accomplished survey is undoubtedly due to the teachers. Without the recognition by them of the importance of this scientific investigation, their cordial cooperation and most painstaking and laborious setting down of all the minute details required from each school, the survey would have been still in the limbo of fancy, to remain there until the census office should have the power to deal with the matter, along with the present ordinary details of this important statistical department. Only when the recording of measurable and non-measurable characters comes to be included in the census, and is dealt with officially, will the importance of much voluntary pioneer work by the teaching profession be fully recognised.

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* The late returns came from the counties of Lanark, Renfrew, Banff, Elgin and Inverness and belonged, in the district scheme, to the first, fourth, eighteenth and ninety-first districts. The total results of observations for these districts are however given in the Appendix tables and not the slightly smaller figures on which the district analysis was made. The figures for the later returns are also of course given along with the others under their respective parishes and counties and were included in all analyses except the district one. The only points therefore to be noted are (1) that the district analysis is based on the slightly smaller general totals and (2) that, in the analysis of Districts I., IV., XVIII. and XCI., the late returns (not to hand at the time of analysis) are excluded.

(4) *The Problems to be discussed.*

Before proceeding to make a brief statement of the analytical methods employed and to follow with a general discussion of the resulting classified data, it seems desirable at this stage to enumerate the problems germane to the survey.

(*a*) The first problem clearly is: How are the children distributed with respect to the various colour classes, what is the proportion of children found in each class, and how does the general distribution among the classes compare with those of the continental countries already surveyed?

The answer to this problem is given (α) in Table XIII., where the general distribution and the percentages of the colour classes are given, and (β) in section (12), where the results are compared with those of continental countries.

(*b*) The second problem deals with relative local differences in each colour class. Considering each colour class or category separately, one must ask, by how much does each locality in Scotland (division, county or district) differ from the remaining population? In other words, is the distribution of colour uniform throughout Scotland, and if not by how much does the proportion for each class in each locality differ from the proportion which would occur on an even distribution of the school population over the whole country? This amount when found for each locality is termed the relative local difference and the complete solution of the problem is reached when significant relative local differences are determined, and separated from those relative local differences which are fair samples of the general population. This problem is dealt with under section (6).

(*c*) The third problem is one bearing on the general resemblance of local populations to the general population. Here hair colour as a character is considered as a whole in each locality, all the classes constituting the character being considered together. Similarly eye colour as a character is considered as a whole in each locality. The distribution in each locality of the classes constituting each character is compared with the corresponding general distribution of the classes for the same characters which is found for the whole country. Considering, in this manner, hair colour collectively or eye colour collectively, do or do not local populations resemble the general population? If local populations do not resemble the general population how far do the actual local frequencies as a whole differ from the corresponding frequencies which would occur on an even distribution of the population throughout the country? In other words, if divergencies from this even distribution occur, what is the relative degree of divergency for each locality? This is, in short, the third problem which is discussed in section (7).

(*d*) The degree of local segregation of each of the colour classes constitutes the fourth problem. If the population is not evenly distributed with respect to the colour classes, which class shows the greatest degree of isolation into separate groups? This can be determined by considering successively the nature of the distribution of relative local differences of each class collectively and without reference as to where each local difference occurs. That is to say the relative local differences of each class are successively considered interlocally as a whole and the variability of each distribution determined. The greater the variability of the distribution of relative local differences for a class the more uneven will be the distribution of the class throughout the country, and the greater will be its massing into groups, and thus the greater will be the local segregation of the class. This problem is considered in section (8).

(*e*) It is important from the eugenic standpoint to know whether pigmentation is associated in any way with disease, inherited or non-inherited defects, race, or with density, fertility or other characters of the population. These problems are considered in section (9).

(*f*) An interesting problem which is concerned with sexual differences is considered under section (10). The problem may be divided up into three parts. 1. In what respects, if in any, do the constants found for boys and girls differ? 2. Are there any significant pigmentation differences between boys and girls? 3. What is the average resemblance between the male and female factors of the population?

(*g*) The next problem is one concerning urban and suburban populations. The questions may be put. 1. Are there any significant differences between the purely urban and the suburban and rural populations, and if so in what respects do they differ? 2. What differences occur (α) within each urban population (*i.e.* intralocally), and (β) between different urban populations (*i.e.* interlocally), and are these differences environmental, racial or both? This problem is dealt with in section (11) with special reference to Glasgow and its environs.

(*h*) A further problem which is of importance turns on the point as to whether hair and eye colours are independent variables or whether they are dependent. It is desirable therefore to know what degree of association, if any, exists between hair and eye colours. If association is found to exist does the relationship found agree or differ with that indicated by former surveys of adults and children. This problem is considered among others in section (12).

(*i*) The pigmentation data present other problems for solution, such as whether brothers and sisters or cousins resemble one another to any degree in hair and eye colour. These problems are not dealt with in this memoir.

(5) *Methods Employed to Determine Significant Differences.*

In making a survey of the measurable physical characters of a population one has not only to ascertain the type and variability of each character but also to consider the relationship of each local group to the general population*. Thus, in the recent investigation on the inmates of asylums it is shown that several physical types exist among the Scottish insane, and that, whether they differ or not from the sane population, local asylum groups generally do not resemble the general insane population. But non-measurable characters can scarcely yet be dealt with in the same way. It has not been found possible up to the present time, for instance, to determine the value of the character, hair colour, just because no quantitative scale based on experience has yet been devised on which to plot the observations in an orderly way indicating increase or decrease of intensity of colour. It is not clear whether such a scale is possible. Experimental work has just been undertaken by the writer which may throw some light on this point. But while hair colour cannot yet be represented on a scale of intensity of colour such as stature or head length, it can be quite properly dealt with under well defined classes or categories. As already explained, the limits of these classes have been defined in the analytical table given in each schedule. What statisticians have here to consider therefore are the frequencies of the various classes individually and collectively without reference as to whether the classes can be arranged on a scale showing grades of intensity of colour. This has been done on a moderate scale for adults†, and it may be well to restate here the methods employed before proceeding to state the results of the analysis.

A population of N individuals is to be considered, each of which possesses the character X. The character X is not measurable but can be divided into m classes. Let $s_1\ s_2 \dots s_m$ be the classes and let the class frequencies for the whole population be respectively $y_{s_1},\ y_{s_2} \dots y_{s_m}$. The population is divided into groups of magnitude n, and each group is observed and classed with respect to the character X. In making the observations, the probability that any person observed (if the operation is a random one) belongs to class s is $y_s/N = p$, and the probability of the person not belonging to that class, but to one of the others is $(1-p) = q$. If the groups are samples drawn from the general population purely at random, the frequency for the class s for each of the groups is therefore equal to $ny_s/N = np = y_s'$, which is thus for the class s the most probable number likely to be drawn in this way; or is, shortly, the theoretical class frequency. It is necessary to consider what would happen if the whole population was observed in unselected groups at random for the following reason. If the observed class frequencies in the various geographical areas actually differed insignificantly from the theoretical class frequencies then it would be clear that the population was evenly distributed with respect to the character. Thus, *so far as this character is*

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* Tocher: *Biometrika*, Vol. v. Part III. pp. 315 et seq.

† Tocher: *Biometrika*, Vol. v. Part III. pp. 335 et seq.

concerned, it would be a homogeneous population. Heterogeneity must be sought for in other characters. If all the physical characters showed homogeneity then it would be clear that one had a common race to deal with. But if, with respect to the character X, the observed and theoretical class frequencies appeared to differ significantly, then the population would not be evenly distributed with respect to X. Instead, there would be excess frequencies in some classes and frequencies falling quite short of theory (*i.e.* the proportional even distribution) in others in various localities or groups. One would then have to ascertain whether the significant differences were racial or due to other influences. The question now is: How can one determine whether any difference between observation and theory is significant or not? In other words, if $y_s'' =$ observed class frequency, how can one measure the significance of $y_s'' - y_s'$? Pearson* has pointed out that the distribution of such differences as $y_s'' - y_s'$, if occurring at random, takes the form of the hypergeometrical series

$$M \frac{pN(pN-1)\ldots(pN-n+1)}{N(N-1)\ldots(N-n+1)} \left\{ 1 + n \frac{qN}{pN-n+1} \right.$$
$$\left. + \frac{n(n-1)}{1.2} \frac{qN(qN-1)}{(pN-n+1)(pN-n+2)} + \ldots \right\},$$

and he has shown that the standard deviation of the distribution is given by

$$\Sigma_{(y_s''-y_s')} = \sqrt{npq\left(1 - \frac{n-1}{N-1}\right)}.$$

The areas on either side of the ordinate which divides the distribution at the abscissal value $(y_s'' - y_s')/\sqrt{npq\,(N-n)/(N-1)}$, are proportional to the probabilities of greater or lesser values than the particular value found occurring in future samples. The areas can be determined when the form of curve is known. In the great majority of cases in this survey, the values of n although fairly large are but small fractions of N, and p is not very small. In such cases the hypergeometrical distribution closely approximates the normal curve, the constants β_1 and β_2 being respectively 0 and 3 within the limits of their probable errors. The modal value of the distribution is the nearest whole integer to $\frac{(qN+1)(n+1)}{N+2}$, which differs insignificantly from the mean, nq. Thus the asymmetry and leptokurtosis are insignificant and therefore the probability of greater or lesser values than that found occurring in future samples can be determined from the tables of the probability integral. In certain cases the fraction $\frac{n}{N}$ is an appreciable one, and in these the asymmetry and leptokurtosis are both significant.

In certain other cases p is rather small. In these cases the interpretation of the value of the standard deviation given, which in itself is correct, requires considerable modification because the hypergeometrical series can be no longer satisfactorily represented by the normal curve. The tables of the probability integral are therefore not applicable and do not give the probabilities. They can be found however when the type and the constants of the curve which fits the hypergeometrical distribution have been determined. Tables* for these extreme cases are in the course of production, but they involve laborious calculation and it may be some time before they are ready. Accordingly special stress must not be laid on the differences found where the value of p is such as to give a significantly asymmetrical distribution of samples from which the probabilities of greater or lesser values in future samples are found.

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* Pearson: *Biometrika*, Vol. v. pp. 173—175.

The form in which each difference has been expressed and studied requires notice. It is obvious that, in considering differences and their standard deviations, one may take the observed absolute numbers and expected absolute values—that is, in the notation herein used, y_s'' and y_s'. Again one could take the observed and theoretical percentages—that is the difference $100\{(y_s''/n)-p\}$; or reckoning y_s' in each case as 100, one could take the difference as $100\{(y_s''/y_s')-1\}$. Now it is easy to see that $\sqrt{npq(N-n)/(N-1)}$, reckoned as a percentage, is $100\sqrt{pq(N-n)/n(N-1)}$, the standard deviation with which $100\{(y_s''/n)-p\}$ has to be compared. Expressed as a coefficient of variation, it is also easily seen to be $100\sqrt{q(N-n)/np(N-1)}$, the variability constant (decreasing as n increases) with which $100\{(y_s''/y_s')-1\}$ has to be compared. Thus there are for selection, according to convenience, in the statistical analysis, the three ratios

$$(1)\quad (y_s''-y_s')/\sqrt{npq(N-n)/(N-1)}.$$

$$(2)\quad 100\{(y_s''/n)-p\}/\sqrt{100^2pq(N-n)/n(N-1)}.$$

$$(3)\quad 100\{(y_s''/y_s')-1\}/100\sqrt{q(N-n)/np(N-1)}.$$

It is perfectly obvious that the above ratios, applied to the data, will give identical results. These ratios will, throughout this memoir, be called *relative local differences* (*RLD*), this term being the one introduced by the writer in a previous investigation to denote the local differences in the physical characters of the Scottish insane†. In determining relative local differences, the first expression, which deals with the absolute figures, has been the one used, the calculations having been performed in duplicate. Since the percentages in district groups have been calculated, it was found convenient to use the second form in cases where it was necessary to compare certain of these districts with the general population.

The following table (Table V.) constructed to illustrate, by means of maps, the relative local differences in the physical characters of the Scottish insane† will be used throughout the memoir both in the text and in the maps, and defines the terms used to indicate the significance or non-significance of the observed results. From what has already been said, these relative local differences when n is fairly

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* *Biometrika*, Vol. v. p. 175.

† Tocher: *Biometrika*, Vol. v. Part III. pp. 317—318; also Table VIII. of that memoir.

TABLE V.

Class Ranges.

The value found compared with the value for the general population is	Specific Term	Class	*RLD.* Range of Class in terms of $(y_s''-y_s')/\Sigma(y_s''-y_s')$
Very much smaller	Distinctly Micrometropic	-4	$-3·5$ upwards
Probably significantly less	Probably Micrometropic	-3	$-2·5$ to $-3·5$
Less but not quite significantly less	Mesometropic	-2	$-1·5$ to $-2·5$
Very slightly less	Mesometropic	-1	$-0·5$ to $-1·5$
Quite insignificantly different	Mesometropic	0	0·5 to $-0·5$
Very slightly greater	Mesometropic	1	0·5 to 1·5
Greater but not quite significantly greater ...	Mesometropic	2	1·5 to 2·5
Probably significantly greater	Probably Megalometropic	3	2·5 to 3·5
Very much greater	Distinctly Megalometropic	4	3·5 upwards

large, but small compared with N and p is not very small, are evidently the abscissal values of the normal curve whose equation is

$$y = \frac{1}{\sqrt{2\pi}} e^{-\frac{x^2}{2}}.$$

These conditions exist for the majority of cases, and here therefore, for any individual result, the probabilities of greater or lesser values can be readily calculated. But in cases where asymmetrical curves result owing to n/N being appreciable, or p small or both, the probabilities, as already stated, cannot be found from the tables of the probability integral, and thus the specific term applied to any class within the range of which the relative local difference falls, may or may not apply in such cases. The terms* denoting the significance of the results in the table of class ranges (Table V.) are therefore intended to be strictly applicable only to relative local differences which are abscissal values of a normal curve, and are applicable to those which are abscissal values of a distinctly asymmetrical curve only as a first approximation. With this reservation those relative local differences which fall beyond $+2$ and -2 may possibly or even probably be significant, those falling beyond $+3$ and -3 may probably be significant, while those falling beyond $+4$ and -4 may be regarded as distinctly significant.

(6) *Relative Local Differences geographically considered. Individual differences of each class.* (*Problem b.*)

I. *Explanatory and Introductory.*

In studying the individual relative local differences of each class (that is the individual relative differences, whether the divisions, counties, districts or other smaller areas are considered) the following plan will be followed with respect to Scotland geographically. The distribution of each class with respect to the eight great divisions of Scotland, as understood by the Registrar-General and used in the census and other official reports, will first be considered. Then the county distributions will be noted and finally the distributions with respect to the smallest unit—the district—will be dealt with. Thus the reader (1) will get an appreciation of the nature of the distribution in general terms, *i.e.* the significant inter-divisional differences will be determined and pointed out; (2) will learn how far counties differ from one another, thus enabling the reader to note intra-divisional as well as inter-county differences; and finally (3) will see what localities influence the various county and divisional differences, thus detecting differences occurring within each county—that is, the significant intra-county or purely local differences. It should be noted that the frequencies of the various classes of a character such as hair colour or eye colour are correlated. Thus an excessive frequency of one class would point to a defect in the frequency of one or more of the other classes. Before describing the various differences, it will be useful here to show the total frequencies of each class and their percentages for the whole of Scotland. These are as follow (Table VI.):

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* Tocher: *Biometrika*, Vol. v. p. 318.

TABLE VI.

Colour Distribution of Scottish Children.

	Hair					Eyes				
	Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark	Totals
Boys A	64312	14162	111569	64511	3212	37788	78140	84334	57504	257766
„ B	24·950	5·494	43·283	25·027	1·246	14·660	30·314	32·717	22·309	per cent.
Girls A	67036	12435	99873	62073	2972	36347	74068	78357	55617	244389
„ B	27·430	5·088	40·866	25·399	1·216	14·873	30·307	32·062	22·758	per cent.

Boys A and Girls A = total frequencies of each class for whole of Scotland for boys and girls respectively.

Boys B and Girls B = percentages of each class for whole of Scotland for boys and girls respectively.

The following tables (Tables VII., VIII. and IX.) give the values of the relative local differences for hair colour and eye colour of both boys and girls. These differences, classed as described in Section 5, are shown in the maps, named in the course of the descriptions of the differences in each colour class in this section (Maps III. to XL.), and are the basis of the following remarks:

TABLE VII.

Relative Local Differences. Divisions.

Values of $(y_s'' - y_s') \Big/ \sqrt{mpq \left\{1 - \left(\frac{n-1}{N-1}\right)\right\}}$.

BOYS.

Division	Hair					Eyes			
	Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark
I.	2·24	1·96	−6·31	2·91	4·08	6·58	−4·68	·03	− ·46
II.	4·36	− ·56	−9·98	5·66	6·60	12·92	·05	−5·67	−4·64
III.	2·13	6·08	−2·57	−1·69	−2·73	3·69	−1·56	2·15	−3·83
IV.	1·25	−2·99	1·64	−1·83	1·08	4·33	−5·82	− ·50	3·31
V.	− ·57	−2·95	−4·67	6·67	3·09	− 1·27	5·48	−1·74	−3·01
VI.	−8·48	−1·70	7·58	·95	− ·96	−14·38	1·96	4·78	4·66
VII.	3·63	1·60	3·88	−7·87	−4·03	1·22	1·55	−2·73	·33
VIII.	3·13	− ·38	−1·79	− ·19	−2·68	2·48	2·23	−2·20	−2·09

GIRLS.

Division	Hair					Eyes			
	Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark
I.	7·20	− ·70	− 4·61	−2·49	2·70	7·19	−2·77	−3·22	·52
II.	4·08	−1·15	−10·13	5·33	9·98	14·25	−1·08	−7·10	−3·01
III.	8·12	5·16	− 4·92	−5·06	−1·28	4·48	−2·10	2·36	−4·13
IV.	4·02	−1·01	− 1·85	−1·61	·32	1·36	−6·50	·75	5·14
V.	− ·24	−2·80	− 2·09	3·33	2·78	− 1·35	6·81	−2·80	−3·20
VI.	−19·99	−1·46	12·60	7·69	−2·73	−11·32	·14	5·03	3·85
VII.	5·68	1·27	1·43	−7·03	−4·15	− ·85	2·41	− ·33	−1·55
VIII.	7·62	− ·50	− 4·68	−2·55	1·10	1·27	4·38	−3·54	−1·94

Explanatory Note on the "Divisions." (See Map I.)

I. = Northern Division (Sutherland group).
II. = North-Western Division (Inverness group).
III. = North-Eastern ,, (Aberdeen group).
IV. = East-Midland ,, (Perth group).
V. = West-Midland ,, (Argyll group).
VI. = South-Western ,, (Ayr group).
VII. = South-Eastern ,, (Lothian group).
VIII. = Southern ,, (Dumfries group).

TABLE VIII.

Relative Local Differences. Counties.

BOYS.

	Hair					Eyes			
	Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark
Aberdeen Co. ...	·33	3·55	-·27	-2·27	1·52	6·56	-1·27	2·38	-6·86
Aberdeen City ...	-1·04	3·55	·07	·40	-5·12	-5·86	1·47	1·71	1·45
Argyll ...	-·81	-·81	-7·59	9·40	2·02	-·47	5·27	-1·08	-4·21
Ayr ...	5·89	-·77	-3·81	-1·02	-·38	6·91	3·26	-5·60	-3·15
Banff ...	1·56	3·84	-1·20	-2·03	-·69	1·10	-4·02	1·48	1·84
Berwick ...	5·72	-1·01	-4·38	-·39	·85	1·64	3·06	-2·60	-1·85
Bute ...	-4·56	·59	2·57	·64	2·57	-4·33	2·56	1·03	-·31
Caithness ...	·18	1·12	-3·25	1·52	5·54	-2·90	-2·21	1·98	2·68
Dumbarton ...	3·07	-2·38	-2·50	·68	1·41	-1·27	4·29	-3·16	-·09
Dumfries ...	2·93	-2·83	1·59	-2·40	-3·34	-3·15	3·36	2·69	-4·06
Edinburgh Co. ...	3·10	·12	1·14	-3·79	-2·63	6·28	-·84	-2·54	-1·55
Edinburgh City ...	3·19	-·45	-·62	-1·66	-2·29	1·30	-1·10	-4·84	5·57
Leith ...	-2·45	1·46	3·32	-1·18	-3·64	-8·94	3·84	2·36	·70
Elgin & Nairn ...	6·15	·61	-3·44	-2·47	-·21	8·82	-3·27	-2·02	-1·61
Fife K. & C. ...	1·26	-2·61	2·40	-2·32	-1·18	-1·43	-1·58	3·19	-·64
Forfar ...	·54	·06	·58	-·66	-2·23	8·12	-3·52	-4·74	2·33
Dundee ...	-3·77	-·33	4·00	-·99	1·37	-·31	-5·92	2·30	4·21
Haddington ...	-·48	1·14	1·52	-2·15	1·13	5·20	-1·26	-1·09	-1·80
Inverness ...	2·17	-·83	-7·00	5·23	4·08	8·82	-·55	-4·79	-1·48
Kincardine ...	-·11	-·16	-3·05	3·98	-1·16	-1·20	3·47	-1·25	-1·41
Kirkcudbright ...	-2·02	·70	-2·04	4·32	-1·33	1·93	1·30	-2·86	·15
Lanark ...	1·62	-·08	·25	-5·34	-·71	-9·04	1·34	6·76	-1·42
Glasgow ...	-12·00	-1·16	7·36	4·57	-1·52	-18·55	1·04	4·95	9·03
Govan ...	-7·80	-·80	7·64	-·54	·05	-·09	-·27	-2·31	2·98
Linlithgow ...	1·37	2·14	2·78	-5·50	-·64	-·84	3·01	·45	-3·12
Orkney ...	3·31	-·91	-2·26	-·34	·38	3·71	·31	1·62	-5·33
Perth ...	4·29	-2·38	-4·52	·98	4·53	3·30	-·34	-3·08	1·04
Renfrew ...	-3·78	-·43	3·56	-·47	1·54	·92	-2·61	1·61	·29
Ross & Cromarty	3·96	·06	-6·99	2·67	5·19	9·29	·64	-3·13	-5·07
Roxburgh ...	4·33	1·25	-1·99	-2·59	-·49	4·54	·74	-5·29	1·28
Selkirk & P. ...	-·82	·64	5·95	-6·19	-·50	1·24	-2·88	2·96	-1·20
Shetland ...	1·84	1·88	-2·87	·21	·95	11·74	-5·06	-3·81	-·09
Stirling ...	-·90	-2·13	-·28	2·08	1·02	1·05	-·08	·28	-1·12
Sutherland ...	-·94	2·20	-4·44	4·84	·10	3·24	-3·05	-·93	1·66
Wigtown ...	·45	1·39	-2·30	1·22	·92	3·74	-2·34	-·32	-·24

TABLE IX.

Relative Local Differences. Counties.

GIRLS.

	Hair					Eyes			
	Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark
Aberdeen Co. ...	5·19	1·49	−2·34	−4·11	2·72	4·36	·17	·52	−4·46
Aberdeen City ...	−·33	2·37	−·11	·53	−5·05	−2·78	−1·21	3·65	−·38
Argyll ...	−·76	−·13	−5·44	5·91	4·26	·56	4·20	−1·17	−3·78
Ayr ...	5·61	−·67	−·75	−4·14	−1·67	7·66	1·24	−2·82	−4·71
Banff ...	4·75	5·58	−2·05	−4·92	−1·79	1·14	−3·00	1·30	·87
Berwick ...	5·67	−·07	−3·26	−1·86	−·97	1·29	2·75	−1·92	−1·96
Bute ...	−1·16	·52	−1·03	2·03	·19	−2·91	2·50	1·42	−1·85
Caithness ...	1·94	−1·18	−1·94	−·08	3·47	−1·27	·04	−·89	2·03
Dumbarton ...	1·88	−2·54	−2·67	2·09	1·16	−2·42	6·93	−3·80	−1·31
Dumfries ...	6·59	−1·11	−2·00	−3·92	−·10	−2·47	3·14	1·77	−3·30
Edinburgh Co. ...	5·88	2·73	1·73	−8·52	−3·38	3·84	−·40	·00	−2·83
Edinburgh City ...	−1·84	−·51	·56	1·03	2·00	−·34	−1·02	−2·83	4·55
Leith ...	·18	−·43	1·76	−·91	−4·18	−8·32	4·32	4·09	−2·22
Elgin & Nairn ...	5·39	·43	−3·66	−1·87	1·03	6·95	−4·60	·54	−1·46
Fife K. & C. ...	7·57	−2·43	−2·21	−2·84	−4·79	−1·94	−2·36	2·49	1·46
Forfar ...	·72	1·14	·34	−1·96	1·05	4·96	−3·21	−4·91	4·78
Dundee ...	−5·95	−·12	3·18	2·08	1·97	−2·16	−6·32	4·49	3·77
Haddington ...	3·59	·54	−2·47	−·83	−1·31	3·34	1·25	−2·48	−1·44
Inverness ...	·92	−1·22	−7·30	5·74	8·68	10·71	−·01	−8·04	−·13
Kincardine ...	4·38	1·48	−4·55	−·33	·94	1·91	4·06	−2·77	−2·99
Kirkcudbright ...	1·41	−·72	−2·14	1·21	·51	−·90	4·65	−2·55	−1·49
Lanark ...	2·44	1·07	1·24	−3·14	−5·18	−5·24	1·58	2·73	−·32
Glasgow ...	−24·17	−1·93	9·85	14·28	1·40	−14·61	−2·16	6·62	7·40
Govan ...	−12·50	·09	9·53	2·22	−·84	−2·07	1·39	−2·35	2·86
Linlithgow ...	4·95	·62	−·97	−3·63	−2·64	·49	1·68	−·58	−1·61
Orkney ...	4·87	−·27	−2·26	−2·29	−·06	4·01	·16	·69	−4·35
Perth ...	3·72	·20	−4·47	·15	3·95	2·93	−·58	−1·82	·17
Renfrew ...	−8·37	−1·33	4·51	3·61	2·16	−2·90	−1·46	2·69	1·08
Ross & Cromarty	4·83	−·38	−6·89	1·69	5·28	9·24	−1·51	−1·87	−4·11
Roxburgh ...	4·45	1·54	−2·40	−2·81	·75	2·43	·70	−4·07	1·71
Selkirk & P. ...	−·61	·71	4·85	−4·96	−1·00	·34	−1·62	2·90	−1·75
Shetland ...	4·57	·89	−3·24	−1·77	1·18	9·73	−4·56	−3·32	·43
Stirling ...	−·79	−2·25	3·33	−1·81	−·01	·55	·65	−·86	−·22
Sutherland ...	3·58	−·44	−2·03	−1·20	·18	4·26	−2·25	−3·74	3·01
Wigtown ...	1·42	−·34	−2·98	1·74	1·38	5·26	−·46	−3·87	·34

II. *Differences in Hair Colour.*

Hair colour of both sexes will first be considered. (α) Fair Hair. (Maps III., IV., XXI., XXII. and XXXIX.) The North-Western, South-Eastern and Southern divisions are significantly fair haired, or, using the term for significant excess of a class, these divisions are megalometropic both for boys and girls. Naming the divisions in a way more readily understood geographically, the Inverness group of counties, the Border counties and the Lothians have the greatest excess of fair hair (♂ and ♀) compared with the general population. The distributions for boys and girls, however, appear to be different. The results for girls show that the whole of Scotland, excepting the West-Midland and South-Western divisions, are megalometropic or conversely—the Argyll and Lanark groups are micrometropic, the proportion of fair hair in these divisions or groups being significantly less than that of the general population. Looking now at the inter-county and intra-county (district) differences it is seen that any megalometropic character in the Northern division is due to Orkney and Shetland and only very slightly to the east coast of Caithness. The following counties north of the Forth are significantly fair haired: viz. Stirling, Perth, Inverness, Ross, Cromarty, Nairn, Elgin and Banff. These are distinctly Highland counties or counties on the Highland line. Examining the districts it is seen that the region of the Cromarty Firth, the region immediately south of the Moray Firth, South Perthshire, South Forfar, except Dundee, the Isle of Lewis, Dunfermline district and the Trossachs, are the specific localities north of the Forth which are significantly fair. Skye and the adjacent mainland are also moderately fair. South of the Forth, Dumbarton (north of Glasgow), Ayr (south of Glasgow), Midlothian and the Border counties are megalometropic. Lanark, excluding Glasgow, is probably megalometropic. The specific localities significantly fair or megalometropic, south of the Forth, are North Ayr, North Lanark, Midlothian, Berwick and a portion of Roxburgh. On the whole the county distributions for boys and girls correspond. Haddington, Fife and Linlithgow are significantly fair haired counties in the girl population. In view of the fact that significant excess appears in so many large areas, one must enquire where the micrometropic population is. The most outstanding cases are the cities of Glasgow, Dundee, Leith and Greenock. The relative difference in Glasgow is so great ($RLD = -12{\cdot}00$ and $-24{\cdot}17$ for boys and girls respectively) as to point to exceptional circumstances with respect to this great city. The colour distribution is entirely different from any other part of Scotland. A separate section will therefore be devoted to Glasgow and to problems bearing on the relationship between density of the population generally and colour. Aberdeen city is like the general population, while Edinburgh is significantly fair haired, slightly more so than the surrounding population. Hawick, Airdrie, Dunfermline, Forfar, Hamilton, Dumbarton and Perth are megalometropic towns; Stirling, Kirkcaldy, Rutherglen, Montrose and Peterhead are micrometropic; while Paisley, Kilmarnock, Ayr, Arbroath, Inverness, Falkirk, Dumfries, Dysart and Galashiels are mesometropic, *i.e.* these towns are like the general population.

Generally speaking, excess of fair hair is found both in the Highlands and the Lowlands in Scotland, but it cannot be said that this class is characteristic of either—the distribution is far from uniform. In the Highlands, fair hair is more characteristic of the boundaries than of the heart of the Highland country. *The Moray and Cromarty Firths, East Perthshire, the Trossachs, Dumbarton, Lewis, and East Caithness encircle and are mostly part of the Highlands, and these districts are significantly fair populations. The Borders, North Ayr, and parts of Lanark and Midlothian, as against Galloway, Selkirk, Peebles, Glasgow, and the region* *surrounding Glasgow, are fair Lowland districts. Orkney and Shetland are both significantly fair, the only distinguishing feature in hair colour among the population of these islands.*

(*β*) Red Hair. (Maps V., VI., XXIII., XXIV. and LX.) Significant excess of red hair is confined (♂ and ♀) to the North-East division; there is a possible significant excess for boys also in the Northern and South-Eastern divisions. The counties of Aberdeen and Banff stand out clearly as having the greatest excess in the North-Eastern division; Midlothian, Roxburgh, Orkney and Shetland (for boys); Linlithgow and Sutherland (for girls) are also megalometropic. Proportions slightly above the average occur in Haddington, the Borders, Galloway, Arran and Caithness (♂), and in Haddington, Lanark, Peebles, Selkirk, Arran, Forfar and Kincardine (♀); but in none of these cases can the differences be said to be at all significant. Only on the border of the North Highlands is there even the slightest excess of red hair. *It is quite clear that the population north of the Grampians and east of the Caledonian Canal is the only one in Scotland where red hair persists quite above the average. Special notice of this peculiarity is taken in a later section.*

TABLE X.

County Specification. Fair Hair. Both Sexes.

The sign ♂ indicates boys only; and ♀, girls only.

Megalometropic		Mesometropic	Micrometropic	
Distinctly	Probably		Probably	Distinctly
Ayr	Dumbarton ♂	*Aberdeen City*		*Dundee*
Berwick	Dumfries ♂	Argyll		*Glasgow*
Elgin & Nairn	Edinburgh Co. ♂	Caithness		*Govan*
Perth	*Edinburgh City* ♂	*Leith*		Renfrew
Ross & Cromarty	Orkney ♂	Forfar		Bute ♂
Roxburgh		Inverness		
Banff ♀		Kirkcudbright		
Aberdeen ♀		Lanark		
Dumfries ♀		Selkirk & Peebles		
Edinburgh Co. ♀		Stirling		
Fife ♀		Wigtown		
Haddington ♀		Aberdeen ♂		
Kincardine ♀		Banff ♂		
Linlithgow ♀		Fife K. & C. ♂		
Orkney ♀		Haddington ♂		
Shetland ♀		Kincardine ♂		
Sutherland ♀		Linlithgow ♂		
		Shetland ♂		
		Sutherland ♂		
		Bute ♀		
		Dumbarton ♀		
		Edinburgh City ♀		

TABLE XI.

County Specification. Red Hair. Both Sexes.

The sign ♂ indicates boys only ; and ♀, girls only.

Megalometropic		Mesometropic	Micrometropic	
Distinctly	Probably		Probably	Distinctly
Banff Aberdeen Co. ♂ *Aberdeen City* ♂	Edinburgh Co. ♀	Argyll Ayr Berwick Bute Caithness *Edinburgh City* *Leith* Elgin & Nairn Forfar *Dundee* Haddington Inverness Kincardine Kirkcudbright Lanark *Glasgow* *Govan* Linlithgow Orkney Perth Renfrew Ross & Cromarty Roxburgh Selkirk Shetland Stirling Sutherland Wigtown Dumbarton ♂ Edinburgh Co. ♂ Aberdeen Co. ♀ *Aberdeen* ♀ Dumfries ♀ Fife K. & C. ♀	Dumfries ♂ Fife K. & C. ♂ Dumbarton ♀	

(γ) Medium Hair. (Maps VII., VIII., XXV. and XXVI.) Excess of medium or brown of various shades is peculiar to the Scottish Midlands, there being corresponding defects in the north, the Borders and Galloway. The East-Midland, South-Western and South-Eastern populous divisions show for boys significant excess. In only one division—the South-Western—is there significant excess among the girls. Among the counties, Renfrew, Selkirk and Peebles are megalometropic for both sexes; Stirling and Midlothian for girls only; Linlithgow, Fife, Dumfries and Haddington for boys only. Glasgow, Dundee and Leith are megalometropic towns. *As will be seen later, brown or medium hair is characteristic of densely populated parts.*

TABLE XII.

County Specification. Medium Hair. Both Sexes.

The sign ♂ indicates boys only; and ♀, girls only.

Megalometropic		Mesometropic	Micrometropic	
Distinctly	Probably		Distinctly	Probably
Glasgow *Govan* Renfrew Selkirk & Peebles *Dundee* ♂	Bute ♂ *Leith* ♂ Linlithgow ♂ *Dundee* ♀ Stirling ♀	Aberdeen Co. *Aberdeen City* Banff Dumfries Edinburgh Co. *Edinburgh City* Fife K. & C. Forfar Haddington Kirkcudbright Lanark Orkney Roxburgh Dumbarton ♂ Stirling ♂ Wigtown ♂ Ayr ♀ Bute ♀ Caithness ♀ *Leith* ♀ Linlithgow ♀ Sutherland ♀	Shetland Caithness ♂ Elgin & Nairn ♂ Kincardine ♂ Berwick ♀ Dumbarton ♀ Wigtown ♀	Argyll Inverness Perth Ross & Cromarty Ayr ♂ Berwick ♂ Sutherland ♂ Elgin & Nairn ♀ Kincardine ♀

(δ) Dark Hair. (Maps IX., X., XXVII. and XXVIII.) The distribution of dark hair is very striking. Significant excess is found in the entire west of Scotland, and compared with the general population there is a corresponding significant defect of this class in the east. The Northern, North-Western and West-Midland divisions (♂) and the North-Western, West-Midland and South-Western divisions (♀) are distinctly megalometropic. The South-Western division for boys shows slight excess. Examining the counties, it is seen that Sutherland, Ross and Cromarty, Inverness, Argyll and Kirkcudbright, all in the west, are for boys megalometropic. Kincardine (♂) is the sole eastern megalometropic county. Significant excess among the girl population occurs only in the counties of Ross and Cromarty, Inverness, Argyll, Renfrew and Wigtown. There is only a slight excess in Kirkcudbright. Examining the districts it is seen that Mull, Jura and the portion of the mainland opposite is the most significantly dark population of Scotland. Then follow the remaining portion of Argyll, the western portions of Inverness, Ross and Cromarty (*excluding Skye*) and Sutherland. Although Ayrshire (♂) is not megalometropic, the southern portion below Ayr itself is, the district analysis showing significant excess in the Doon region and also in the southern portion of Galloway (Wigtown and South Kirkcudbright). The district analysis shows the same restricted nature of the distribution in the girl population. Wigtown is the only portion of Galloway with excess. The extreme north of Ayrshire (and not the south as among ♂), and an isolated portion on the Moray Firth (Dornoch and Tain) are also dark-haired districts. Dundee, Edinburgh and Aberdeen show among the girls a slight excess of dark hair, Dundee being the most marked. Summing up the results for this class, *it is found that the Highlands, Galloway and the city of Glasgow are the populations which show significant excess of dark hair.* There is therefore clearly a sharp distinction geographically, and, as will be shown later, racially in the distribution of this class of hair colour. The east, excepting the slight excesses in Edinburgh and Aberdeen cities (♀), a small portion of the coast-line north of Montrose and Donside (♂) is characterised by a significant defect in the expected proportion of dark hair compared with what would occur on an even distribution of that class throughout the whole country.

TABLE XIII.

County Specification. Dark Hair. Both Sexes.

The sign ♂ indicates boys only; and ♀, girls only

Megalometropic		Mesometropic	Micrometropic	
Distinctly	Probably		Probably	Distinctly
Argyll Inverness *Glasgow* Kincardine ♂ Kirkcudbright ♂ Sutherland ♂ Renfrew ♀	Ross & Cromarty ♂	*Aberdeen City* Berwick Bute Caithness Dumbarton *Edinburgh City* *Leith* Elgin & Nairn Forfar *Dundee* Haddington *Govan* Orkney Perth Shetland Stirling Wigtown Aberdeen Co. ♂ Ayr ♂ Banff ♂ Dumfries ♂ Fife K. & C. ♂ Renfrew ♂ Kincardine ♀ Kirkcudbright ♀ Ross & Cromarty ♀ Sutherland ♀	Roxburgh Fife ♀ Lanark ♀	Edinburgh Co. Linlithgow Selkirk & Peebles Lanark ♂ Aberdeen Co. ♀ Ayr ♀ Banff ♀ Dumfries ♀

(ε) Jet Black Hair. (Maps XI., XII., XXIX. and XXX.) In a general way, the distribution of jet black hair resembles that of dark hair. While this however is the case, the jet black class seems to be more scattered than the dark-haired class. Taking the divisions first, the Northern, North-Western and West-Midland divisions are clearly megalometropic both for boys and girls. The North-Eastern, South-Eastern and Southern (♂), the South-Eastern and South-Western (♀), are micrometropic; the remaining divisions are fair samples of the general population—they are mesometropic. Surveying the counties, it is seen that the excess in the Northern division is due to Caithness; the excess of the North-Western division is equally divided among the respective counties, while the excess of the West-Midland division is due to Argyll and Bute and slightly to Dumbarton. In the South-Western division, although itself meso- (♀) or micrometropic (♂), the county of Renfrew stands alone in showing significant excess of this class. The East-Midland and North-Eastern divisions are not at all uniform in their distribution of jet black hair. Thus (♂ and ♀) Perth resembles the contiguous county of Argyll in showing excess; only the eastern portion (♂) is micrometropic. Among girls, Fife is the only eastern county in this division which is micrometropic. The other eastern counties and Dundee show a slight excess over the general population. Aberdeenshire (but not Aberdeen city) stands out as megalometropic, although the North-Eastern division itself is either meso- (♀) or micrometropic (♂). Taking now a more detailed view of the distribution locally, one notes that, starting from John o' Groat's, excess of jet black hair runs along the coast to Inverness, where it leaves the coast and permeates the upper regions of the Findhorn, Spey and Donside. A slight excess is found along the Buchan coast. It is absent again until the Forfar and Fife coasts are reached, when again slight excess is noticed. It is in defect south of the Forth on the coastline. Running inwards from Fife and Forfar the excess increases and reaches a maximum in North Perthshire, where it unites with the excess in the Spey valley and the slight excess of Donside. Southwards from Perthshire it reaches Stirling, Dumbarton, and a portion of Renfrew. Northwards it runs through Inverness, part of Ross, and on to Skye and Lewis. It avoids the main portion of Argyll where there is great excess of dark hair, but affects the portion contiguous to Skye and Inverness, *i.e.* the mainland to Ardnamurchan Point, and the Isles of Mull, Tyree, Coll and Rum. An isolated spot occurs in Wigtown (♀), and in North Ayr and the contiguous portion of Lanark (♂). *A general view of this class, small numerically, shows that jet black hair, like dark hair, is characteristic of Highland counties, but that the distribution is not so restricted as in the case of dark. There is a greater scatter in the distribution for boys than in the corresponding distribution for the girl population.*

TABLE XIV.

County Specification. Jet Black Hair. Both Sexes.

The sign ♂ indicates boys only ; and ♀, girls only.

Megalometropic		Mesometropic	Micrometropic	
Distinctly	Probably		Probably	Distinctly
Inverness Perth Ross & Cromarty Caithness ♂ Argyll ♀	Bute ♂ *Aberdeen City* ♀ Caithness ♀	Ayr Banff Berwick Dumbarton *Edinburgh City* Elgin & Nairn Forfar *Dundee* Haddington Kincardine Kirkcudbright *Glasgow* *Govan* Orkney Renfrew Roxburgh Selkirk & Peebles Shetland Stirling Sutherland Wigtown Aberdeen Co. ♂ Argyll ♂ Fife K. & C. ♂ Lanark ♂ Linlithgow ♂ Bute ♀ Dumfries ♀	Edinburgh Co. Dumfries ♂ Linlithgow ♀	*Aberdeen City* *Leith* Fife K. & C. ♀ Lanark ♀

III. *Differences in Eye Colour.* (*a*) Blue Eyes. (Maps XIII., XIV., XXXI. and XXXII.) The general percentage for blue eyes among boys is 14·66 and among girls is 14·87. The greatest excess is found in Shetland and the smallest percentage in Glasgow. Noting first the general distribution it is seen that the north is distinctly the blue-eyed region. The Northern, North-Western, North-Eastern (♂ and ♀) and East-Midland (♂) are significantly blue-eyed. The South-Eastern (♂) and Southern (♂ and ♀) show slight excess. The South-Western (♂ and ♀) is distinctly micrometropic—there is quite a deficiency of blue eyes in this division compared with the general population. The West-Midland division is only slightly micrometropic. Examining the county distributions, one finds that Orkney, Shetland and Sutherland (but not Caithness) are significantly blue-eyed; all the counties in the North-Western division (♂ and ♀) are also megalometropic; in the East-Midland division, Perth and Forfar (but not Kincardine, the coast, Dundee and Fife) are also quite significant in their excess of blue eyes. Midlothian and Haddington (South-Eastern division) show significant excess; Berwick (♂) only a slight excess. Wigtown and Roxburgh (of the Southern division) and only Ayr (South-Western division) are megalometropic counties with respect to blue eyes. On the county basis of analysis, the tract of country stretching from Fife through the Midlands to Dumbarton and southwards through Stirling, Linlithgow, Lanark, Renfrew, Peebles, Selkirk, Kirkcudbright and Dumfries, is characterised by a deficiency (in many localities highly significant) of the blue-eyed class of children. Argyll alone of the Highland counties shows no bias in favour of blue eyes; it is like the general population. Examining the distribution from the results of the district analysis it is seen that there is no significant excess on the east coast except in the Elgin district. Inwards from Elgin, north to Sutherland, west to Lewis, south to the border of Argyll and North Perthshire, and east through the Spey region to West Aberdeenshire, blue eyes is quite in excess of the general population both for boys and girls. The excess is small in Mid Perthshire, increases in the south of the county and diminishes rapidly in passing into Stirlingshire and the populous region between the Forth and the Clyde. Turning eastwards, the excess becomes significant in North-East Lanarkshire and the neighbourhood of Linlithgow. In the Lothians, the excess found there by the county analysis is shown by the district analysis to be fairly evenly distributed. No great city shows excess of the blue-eyed population. On the contrary, there is a significant defect in each,

TABLE XV.

County Specification. Blue Eyes. Both Sexes.

The sign ♂ indicates boys only; and ♀, girls only.

Megalometropic		Mesometropic	Micrometropic	
Distinctly	Probably		Probably	Distinctly
Aberdeen Co. Ayr Edinburgh Co. Elgin & Nairn Forfar Inverness Orkney Ross & Cromarty Shetland Wigtown Haddington ♂ Roxburgh ♂ Sutherland ♀	Perth Sutherland ♂ Haddington ♀	Argyll Banff Berwick Dumbarton *Edinburgh City* Fife K. & C. *Dundee* Kincardine Kirkcudbright *Govan* Linlithgow Selkirk & Peebles Stirling Renfrew ♂ Caithness ♀ Dumfries ♀ Roxburgh ♀	Caithness ♂ Dumfries ♂ *Aberdeen City* ♀ Bute ♀ Renfrew ♀	*Leith* Lanark *Glasgow* *Aberdeen City* ♂ Bute ♂

excepting Edinburgh (♂ and ♀), and Dundee (♂), which approximate the general population in distribution.

Looking at the distribution of blue eyes in the division and county maps, it seems a very wide one. That is, geographically considered it is wide, but it must of course be kept in mind that the areas shown are very sparsely populated. The populous area between Edinburgh and Glasgow and the populous centres are mainly defective in blue eyes. Thus the question of density again arises. It will be seen later that just as fair hair is negatively correlated to density so also are blue eyes.

(β) Light Eyes. (Maps XV., XVI., XXXIII. and XXXIV.) The proportion of light-eyed children in the general population is 30·314 per cent. for boys and 30·307 per cent. for girls. The West-Midland division (that is, the Argyll group) stands out prominently as the only division where significant excess of light eyes occurs both among boys and girls. The Southern or Galloway division is also significant for girls, while the South-Eastern or Midlothian division (♂ and ♀), Galloway (♂), the South-Western (♂) have a moderate but not a significant

TABLE XVI.

County Specification. Light Eyes. Both Sexes.

The sign ♂ indicates boys only; and ♀, girls only.

Megalometropic		Mesometropic	Micrometropic	
Distinctly	Probably		Probably	Distinctly
Argyll Dumbarton *Leith* Kincardine ♀ Kirkcudbright ♀	Berwick Dumfries Ayr ♂ Bute ♂ Kincardine ♂ Linlithgow ♂	Aberdeen Co. *Aberdeen City* Caithness Edinburgh Co. *Edinburgh City* Fife K. & C. Haddington Inverness Lanark *Glasgow* *Govan* Orkney Perth Ross & Cromarty Roxburgh Stirling Wigtown Kirkcudbright ♂ Ayr ♀ Bute ♀ Linlithgow ♀ Renfrew ♀ Selkirk & Peebles ♀ Sutherland ♀	Elgin & Nairn ♂ Renfrew ♂ Selkirk & Peebles ♂ Sutherland ♂ Banff ♀ Forfar ♀	*Dundee* Shetland Banff ♂ Forfar ♂ Elgin & Nairn ♀

excess of this class. It is seen from the county analysis that Argyll and Arran account for the excess in the West Midland division (♂ and ♀), Dumbarton also contributing in the case of the girl population. Taking the more local view revealed by the district analysis, it is found that the excess in Argyll thins off through Inverness to Ross, where it disappears. It extends eastwards and northwards through Mid Perthshire and over to Deeside and the Kincardine coast. All these are thinly populated districts. In the populous districts between Edinburgh and Glasgow excess appears sporadically here and there. It runs from Glasgow and Greenock through Renfrew, North Ayr to Kirkcudbright and South Dumfries, a slight break occurring in the district inland from the town of Ayr. Finally, south of the Lothians, a tract from Peebles to Berwick shows moderate excess. Passing from the purely local distribution to the distribution in a general sense, *it is quite clear that the light-eyed class is more characteristic of the south than of the north. The excess is more marked in the girl population.* Renfrew, Selkirk and Peebles are the exceptions. These counties are slightly micrometropic, or, compared with the general population, the proportion of the light-eyed class is scarcely so great, although not significantly less.

(γ) Medium Eyes. (Maps XVII., XVIII. XXXV. and XXXVI.) Turning now to the mixed class of eye defined as medium, it is found that there is 32·72 per cent. of this class for boys and 32·06 per cent. for girls in the general population. The only division in Scotland where this class is in significant excess is the populous South-Western division or Lanark group of counties. This result is found for both boys and girls. The North-Eastern division or Aberdeen group shows a moderate excess (♂ and ♀), but the excess is not greater than could quite possibly occur in making a random selection of the same number from the general population. Examining the distribution with respect to counties, it is seen that Lanark (excluding Glasgow), Dumfries, Selkirk and Peebles—just those counties deficient in all the other classes (excepting Dumfries which has also excess of light eyes)—are the megalometropic counties of this class. These counties are all contiguous and the result is common to both boys and girls. The counties of Fife and Aberdeen and the cities of Dundee and Aberdeen have also an excess of medium eyes (♂ and ♀). Caithness (♂) and the Orkney Islands show a moderate excess of the class. Taking the local distribution, it is found that West Renfrew, North Lanark stretching into Stirling, Selkirk and the town of Dumfries, are the areas where the greatest excess is shown in these counties. West Fife in Fifeshire, the southern portion of the Buchan coast in Aberdeenshire, account for the moderate excess found in these counties. The coast from John o' Groat's to Banff, with one or two local exceptions, shows an excess of the medium class. Taking a general view of the distribution of medium eyes, *it is seen that excess of the class is restricted to an area commencing with Fife and extending right to Dumfries through Lanark. The other regions of excess are more or less detached from this region.*

TABLE XVII.

County Specification. Medium Eyes. Both Sexes.

The sign ♂ indicates boys only; and ♀, girls only.

Megalometropic		Mesometropic	Micrometropic	
Distinctly	Probably		Probably	Distinctly
Glasgow Lanark ♂ *Aberdeen City* ♀ *Leith* ♀ *Dundee* ♀	Selkirk & Peebles Dumfries ♂ Fife K. & C. ♂ Lanark ♀ Renfrew ♀	Aberdeen Co. Argyll Banff Bute Caithness Elgin & Nairn Haddington *Govan* Linlithgow Orkney Stirling *Aberdeen City* ♂ *Leith* ♂ *Dundee* ♂ Kincardine ♂ Renfrew ♂ Sutherland ♂ Wigtown ♂ Berwick ♀ Dumfries ♀ Edinburgh Co. ♀ Fife ♀ Perth ♀ Ross & Cromarty ♀	Kirkcudbright Berwick ♂ Dumbarton ♂ Edinburgh Co. ♂ Perth ♂ Ross & Cromarty ♂ Ayr ♀ *Edinburgh* ♀ Kincardine ♀ Shetland ♀	Forfar Inverness Roxburgh Ayr ♂ *Edinburgh City* ♂ Shetland ♂ Dumbarton ♀ Sutherland ♀ Wigtown ♀

(δ) Dark Eyes. (Maps XIX., XX., XXXVII. and XXXVIII.) The percentage of dark eyes in the general population of boys is 22·31; in the general girl population it is 22·76. The distribution of dark eyes from the point of view of the 'division' analysis shows excesses in the South-Western or Lanark division and the East-Midland or Perth-Forfar division. The buffer county of Stirling, belonging to the West-Midland division, resembles the general population. The North-Western, West-Midland and North-Eastern divisions are all distinctly micrometropic (both ♂ and ♀) for this class. The other divisions are slightly micrometropic or are mesometropic. Examining the results of the county analysis it is noted that Dundee city and Forfar county are responsible for the significant excess in the East-Midland division, while Glasgow alone is responsible for the excess in the South-Western division. Outside these divisions there is a probably significant excess in the counties of Caithness and Sutherland. A slight excess occurs in Banffshire as also in the county of Roxburgh. Taking a local view it is found that an excess occurs in the south and east of the county of Lanark, in South Ayrshire, East Fife and the neighbourhood of Perth, besides the cases just mentioned. *The most striking feature in the distribution of dark eyes is the* *fact that excess is in the main confined to the great cities. These cities are deficient in blue eyes. There does not seem to be any great bias in favour of or against light and medium eyes, but there does seem to be a bias in favour of dark as against blue in the chief cities of Scotland.*

TABLE XVIII.

County Specification. Dark Eyes. Both Sexes.

The sign ♂ indicates boys only; and ♀, girls only.

Megalometropic		Mesometropic	Micrometropic	
Distinctly	Probably		Probably	Distinctly
Edinburgh City *Dundee* *Glasgow* Forfar ♀	*Govan* Caithness ♂ Sutherland ♀	*Aberdeen City* Banff Berwick Bute Dumbarton *Leith* Elgin & Nairn Fife K. & C. Haddington Inverness Kirkcudbright Lanark Perth Renfrew Roxburgh Selkirk & Peebles Shetland Stirling Wigtown Edinburgh Co. ♂ Forfar ♂ Kincardine ♂ Sutherland ♂ Caithness ♀ Linlithgow ♀	Ayr ♂ Linlithgow ♂ Dumfries ♀ Edinburgh Co. ♀ Kincardine ♀	Aberdeen Co. Argyll Orkney Ross & Cromarty Dumfries ♂ Ayr ♀

(7) *The General Resemblance of Local Populations to the General Population.*

I. Introductory. II. Hair Colour as a Character, all Classes constituting the Character being considered together. III. Eye Colour as a Character, all Classes constituting the Character being considered together.

I. *Introductory.* (α) Class frequencies constituting a character are here considered as a whole for each locality (division, county or district), that is to say, intralocally and collectively, and compared with the proportional class frequencies of the general population. (β) As an alternative method, leading to the same result, class frequencies collectively of one locality are compared with the class frequencies collectively of the remaining population and the extent of divergency of the local population measured.

In the previous section the difference between each local group and the general population, *i.e.* the (RLD)'s for each colour class, were detected and discussed. In doing so, the significance or non-significance of these differences for each local group (division, county or district) was determined for each colour class or category. It has been noted that for each class of hair colour or of eye colour, many localities exhibit significant differences from the general population. In others the differences may be insignificant, while in a few localities the differences may be considerable although not quite significant. But it is possible that a locality may exhibit a difference or differences almost or just significant for one or more colour classes and yet, when the differences of all the classes constituting the character (either hair colour or eye colour) in any one locality are considered collectively, these differences as a whole may quite conceivably occur even if the locality in question were a fair sample of the general population. A comparison between the entire pigmentation of each local group and the entire pigmentation of the general population is therefore necessary, in order to detect what local groups really diverge and what local groups do not diverge significantly from the general population, for the two characters under consideration, namely, hair colour and eye colour. In other words, the degree of general resemblance of local populations (firstly in hair colour and secondly in eye colour) to the general population is to be determined. Such a determination can be made at least in two ways, and has already been made in the pigmentation of one fairly long series, namely, the Scottish Insane.

(*a*) One can observe for each locality how closely the observed frequencies of the various classes of hair colour or eye colour as a group correspond to their respective theoretical frequencies—the theoretical frequencies meaning of course, as already noted, those which would be got if, for each locality, the frequencies of the various classes constituting the character were proportionally the same as the frequencies found in the general population The probability that differences in the class frequencies would arise at random in any locality as great as, or greater than, the observed set of differences in class frequencies, can be found by evaluating

$$P=\sqrt{\frac{2}{\pi}}\int_{\chi}^{\infty} e^{-\frac{1}{2}\chi^2}\,d\chi+\sqrt{\frac{2}{\pi}}\,e^{-\frac{1}{2}\chi^2}\left(\frac{\chi}{1}+\frac{\chi^3}{1.3}+\frac{\chi^5}{1.3.5}+\dots+\frac{\chi^{n'-3}}{1.3.5\dots(n'-3)}\right)$$

if n' be even, and

$$P=e^{-\frac{1}{2}\chi^2}\left(1+\frac{\chi^2}{2}+\frac{\chi^4}{2.4}+\frac{\chi^6}{2.4.6}+\dots+\frac{\chi^{n'-3}}{2.4.6\dots(n'-3)}\right)$$

if n' be odd,

where $n'=n+1$ classes in the series constituting the character, $m_r=$ theoretical frequency of any class, $m_r'=$ observed frequency of any class and

$$\chi^2=S\left\{\frac{(m_r-m_r')^2}{m_r}\right\}.$$

This is Pearson's test of goodness of fit* and is applicable, in the manner above stated, to the present data.

(β) One can determine the divergency in hair colour or eye colour of any locality from the remaining population by measuring how far the local group deviates from being a random sample of the general population. This can be done by forming a divergency table and evaluating the mean square contingency coefficient which measures the degree of departure of the local group from complete resemblance to the general population, or the degree of relative divergency of the local group. Such tables† have already been formed for the purpose of determining the relative divergency of the local insane from the general insane population with respect to pigmentation. In a divergency table two groups of the population are dealt with, the local group and the remaining population, but of course the number of classes is not limited. In this investigation the number of classes is small, five for hair colour and four for eye colour. The frequencies for a particular class, S, of the two groups form a column of the table, while the frequencies of all the different classes of either group form a row of the table. If $\chi'^2 =$ the total square contingency coefficient and $\chi^2 = S\left\{\frac{(m_r - m_r')^2}{m_r}\right\}$; $n =$ number in any local group and $N =$ total population, then the relation $\chi'^2 = \frac{N}{N-n}\chi^2$ holds between χ'^2 and χ^2; or χ^2 is a fraction of the total square contingency, being, as seen in the working, a partial summation of χ'^2. The mean square contingency coefficient is of course

$$C_1 = \sqrt{\frac{\chi'^2/N}{1 + \chi'^2/N}}.$$

Since χ^2 has already been calculated, the above formula need not be used. In terms of χ^2

$$C_1 = Q = \sqrt{\frac{\chi^2}{N - n + \chi^2}},$$

and is readily obtained. Since Q measures the divergence of a local group from the remaining population, it is called the *divergency coefficient.* The probable errors of Q have not been evaluated, except in one or two instances. It is sufficient to note that any value of $Q > \cdot 008$ in the present series is probably significant. The values of Q and $\log P$ have been calculated for all the forms of local groups, namely, divisions, counties and districts, and are given in the following tables (Tables XIX., XX., XXI. and XXII.). These two sets of constants have been classed, the classification being the same as that previously adopted for the pigmentation of adults‡. As may be seen from the maps, Class O with values of $\log P < \bar{3}$ and $Q < \cdot 008$ is the non-significant class, the localities belonging to this class being similar on the whole to the general population.

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* *Phil. Mag.* Vol. I. pp. 157—175, July 1900.

† Tocher: *Biometrika*, Vol. v. pp. 333, 334. For theory and probable errors see Pearson, *Biometrika*, Vol. v. pp. 198—203.

‡ Tocher: *Biometrika*, Vol. v. pp. 335—340.

II. *Hair colour.* (α) *Divisions.* Considering first the divisions it is seen on referring to the table (Table XIX.) and maps (Maps XLI. and XLII.) that the East-Midland division resembles the general population in hair colour, both boys and girls, more than in any part of Scotland. The Southern division (♂) and the West-Midland division (♀) approximate more closely to the general population in the distributions of hair colour than the remaining divisions. All the other divisions diverge widely from the general population. The divergency is greatest in the North-Western division for both sexes. This is clearly due to the excesses of dark, jet black and fair hair in this division and the comparative absence of medium. Red hair is only slightly in defect in the division.

TABLE XIX.

Divergency in Hair Colour and Eye Colour. Divisions.

Division of Scotland	Hair				Eyes			
	Boys		Girls		Boys		Girls	
	Log *P*	*Q*	Log *P*	*Q*	Log *P*	*Q*	Log *P*	*Q*
1	$\overline{10}\cdot3$	·0143	$\overline{12}\cdot3$	·0160	$\overline{11}\cdot7$	·0143	$\overline{12}\cdot8$	·0152
2	$\overline{28}\cdot9$	·0231	$\overline{39}\cdot5$	·0281	$\overline{37}\cdot2$	·0265	$\overline{44}\cdot1$	·0296
3	$\overline{9}\cdot8$	·0141	$\overline{19}\cdot5$	·0210	$\overline{5}\cdot4$	·0104	$\overline{7}\cdot7$	·0123
4	$\overline{2}\cdot1$	·0076	$\overline{3}\cdot8$	·0083	$\overline{9}\cdot8$	·0137	$\overline{9}\cdot2$	·0146
5	$\overline{12}\cdot8$	·0157	$\overline{5}\cdot9$	·0103	$\overline{6}\cdot4$	·0110	$\overline{9}\cdot3$	·0139
6	$\overline{11}\cdot3$	·0188	$\overline{47}\cdot0$	·0380	$\overline{28}\cdot8$	·0286	$\overline{18}\cdot5$	·0237
7	$\overline{15}\cdot7$	·0180	$\overline{14}\cdot4$	·0181	$\overline{2}\cdot7$	·0058	$\overline{1}\cdot1$	·0052
8	$\overline{3}\cdot6$	·0080	$\overline{12}\cdot9$	·0158	$\overline{3}\cdot4$	·0077	$\overline{5}\cdot2$	·0103

(β) Examining the general distributions in the county groups, it is noted that the eastern counties generally can passably be described as samples of the general population. The Northern Isles (♂), Aberdeen (♂), Kincardine (♂), Forfar (♂ and ♀), excluding Dundee, Fife (♂), Haddington (♂), Stirling, right to Dumbarton in the West (♂ and ♀), and also Lanark (♂), excluding Glasgow, show, by their divergency coefficients being small, < ·008, that their populations approximate the general population in hair colour. Kirkcudbright and Wigtown in the extreme south are also like the general population. The rest of Scotland shows great divergency from the general population in its distribution of hair colour. For instance the north-west region, owing to both its darkness and fairness, and the south-east region contiguous to the Border, owing to its fairness and brownness, are widely divergent. Can any reason or reasons be assigned why certain counties or areas are more like or more unlike the general population than others? References to the maps (Maps XLIII. to XLVI.) and to the following table (Table XXIII.) show that at least for the boy population the counties which show least divergency for hair colour are just those counties densely populated, Lanark, Stirling and the like.

It must be remembered that the four great cities, Glasgow, Edinburgh, Dundee and Aberdeen, are excluded from the county analysis. Three of these, Glasgow, Dundee and Aberdeen, show significant divergency, that of Glasgow being very great. Edinburgh, however, resembles the general population.

Now if an urban population consisted of persons coming from all parts of the country indiscriminately, each group in the densely populated area would be a fair

TABLE XX.

Divergency in Hair Colour and Eye Colour. Counties.

Counties	Hair				Eyes			
	Boys		Girls		Boys		Girls	
	Log P	Q	Log P	Q	Log P	Q	Log P	Q
Aberdeen Co. ...	$\overline{3}\cdot2$	·0084	$\overline{5}\cdot6$	·0105	$\overline{16}\cdot8$	·0174	$\overline{6}\cdot1$	·0114
Aberdeen City ...	$\overline{7}\cdot3$	·0123	$\overline{6}\cdot7$	·0114	$\overline{7}\cdot5$	·0116	$\overline{3}\cdot1$	·0083
Argyll ...	$\overline{21}\cdot5$	·0201	$\overline{12}\cdot3$	·0159	$\overline{7}\cdot4$	·0115	$\overline{5}\cdot4$	·0100
Ayr ...	$\overline{8}\cdot0$	·0118	$\overline{7}\cdot3$	·0126	$\overline{15}\cdot2$	·0173	$\overline{15}\cdot9$	·0173
Banff ...	$\overline{4}\cdot7$	·0088	$\overline{14}\cdot7$	·0169	$\overline{3}\cdot0$	·0080	$\overline{2}\cdot5$	·0061
Berwick ...	$\overline{7}\cdot2$	·0120	$\overline{6}\cdot1$	·0116	$\overline{3}\cdot1$	·0079	$\overline{3}\cdot9$	·0070
Bute ...	$\overline{5}\cdot4$	·0101	$\overline{1}\cdot5$	·0045	$\overline{6}\cdot0$	·0091	$\overline{3}\cdot2$	·0080
Caithness ...	$\overline{8}\cdot9$	·0124	$\overline{3}\cdot1$	·0086	$\overline{4}\cdot5$	·0085	$\overline{1}\cdot2$	·0046
Dumbarton ...	$\overline{3}\cdot1$	·0084	$\overline{3}\cdot3$	·0085	$\overline{4}\cdot1$	·0090	$\overline{10}\cdot2$	·0142
Dumfries ...	$\overline{6}\cdot7$	·0109	$\overline{9}\cdot5$	·0138	$\overline{7}\cdot4$	·0115	$\overline{5}\cdot8$	·0096
Edinburgh Co. ...	$\overline{5}\cdot7$	·0100	$\overline{20}\cdot6$	·0201	$\overline{8}\cdot1$	·0125	$\overline{4}\cdot6$	·0088
Edinburgh City ...	$\overline{3}\cdot7$	·0077	$\overline{1}\cdot1$	·0056	$\overline{9}\cdot9$	·0128	$\overline{6}\cdot0$	·0095
Leith City ...	$\overline{5}\cdot4$	·0102	$\overline{4}\cdot8$	·0090	$\overline{17}\cdot3$	·0179	$\overline{18}\cdot4$	·0189
Elgin & Nairn ...	$\overline{8}\cdot7$	·0125	$\overline{6}\cdot2$	·0116	$\overline{18}\cdot0$	·0175	$\overline{12}\cdot4$	·0154
Fife K. & C. ...	$\overline{3}\cdot6$	·0080	$\overline{15}\cdot5$	·0179	$\overline{2}\cdot3$	·0064	$\overline{4}\cdot8$	·0073
Forfar ...	$\overline{1}\cdot4$	·0047	$\overline{1}\cdot4$	·0048	$\overline{17}\cdot1$	·0181	$\overline{13}\cdot7$	·0159
Dundee City ...	$\overline{4}\cdot4$	·0093	$\overline{7}\cdot2$	·0126	$\overline{9}\cdot9$	·0127	$\overline{12}\cdot9$	·0152
Haddington ...	$\overline{1}\cdot1$	·0054	$\overline{3}\cdot6$	·0080	$\overline{6}\cdot7$	·0103	$\overline{3}\cdot0$	·0082
Inverness ...	$\overline{14}\cdot9$	·0163	$\overline{27}\cdot6$	·0233	$\overline{17}\cdot0$	·0180	$\overline{30}\cdot8$	·0241
Kincardine ...	$\overline{3}\cdot0$	·0085	$\overline{6}\cdot9$	·0109	$\overline{3}\cdot9$	·0069	$\overline{6}\cdot9$	·0105
Kirkcudbright ...	$\overline{4}\cdot4$	·0092	$\overline{1}\cdot3$	·0050	$\overline{2}\cdot3$	·0062	$\overline{5}\cdot9$	·0095
Lanark ...	$\overline{1}\cdot6$	·0043	$\overline{7}\cdot6$	·0128	$\overline{19}\cdot2$	·0200	$\overline{6}\cdot8$	·0111
Glasgow ...	$\overline{29}\cdot5$	·0248	$\overline{120}\cdot0$	·0510	$\overline{71}\cdot3$	·0381	$\overline{49}\cdot8$	·0324
Govan ...	$\overline{16}\cdot9$	·0176	$\overline{34}\cdot0$	·0265	$\overline{2}\cdot2$	·0064	$\overline{3}\cdot4$	·0078
Linlithgow ...	$\overline{6}\cdot2$	·0114	$\overline{7}\cdot7$	·0120	$\overline{3}\cdot4$	·0075	$\overline{1}\cdot4$	·0042
Orkney ...	$\overline{2}\cdot2$	·0069	$\overline{5}\cdot9$	·0100	$\overline{9}\cdot0$	·0118	$\overline{6}\cdot5$	·0108
Perth ...	$\overline{10}\cdot5$	·0142	$\overline{7}\cdot4$	·0124	$\overline{3}\cdot0$	·0072	$\overline{2}\cdot4$	·0063
Renfrew ...	$\overline{4}\cdot8$	·0089	$\overline{15}\cdot3$	·0180	$\overline{2}\cdot9$	·0080	$\overline{3}\cdot5$	·0077
Ross & Cromarty	$\overline{14}\cdot3$	·0167	$\overline{15}\cdot6$	·0175	$\overline{21}\cdot5$	·0197	$\overline{19}\cdot8$	·0192
Roxburgh ...	$\overline{4}\cdot1$	·0095	$\overline{5}\cdot5$	·0104	$\overline{8}\cdot5$	·0121	$\overline{4}\cdot5$	·0088
Selkirk & Peebles	$\overline{10}\cdot7$	·0139	$\overline{7}\cdot9$	·0118	$\overline{3}\cdot5$	·0074	$\overline{2}\cdot3$	·0064
Shetland ...	$\overline{2}\cdot3$	·0067	$\overline{5}\cdot6$	·0103	$\overline{31}\cdot6$	·0237	$\overline{22}\cdot7$	·0205
Stirling ...	$\overline{2}\cdot8$	·0060	$\overline{3}\cdot9$	·0076	$\overline{1}\cdot8$	·0027	$\overline{1}\cdot9$	·0021
Sutherland ...	$\overline{7}\cdot9$	·0116	$\overline{2}\cdot1$	·0073	$\overline{4}\cdot6$	·0084	$\overline{7}\cdot0$	·0120
Wigtown ...	$\overline{1}\cdot2$	·0052	$\overline{2}\cdot4$	·0067	$\overline{3}\cdot1$	·0078	$\overline{7}\cdot4$	·0118

TABLE XXI.

Divergency in Hair Colour. Districts.

Number of District	Log P		Class		Number of District	Log P		Class	
	Boys	Girls	Boys	Girls		Boys	Girls	Boys	Girls
1	$\bar{3}\cdot58$	$\bar{2}\cdot13$	0	0	*57*	$\bar{5}\cdot52$	$\bar{4}\cdot86$	I	I
2	$\overline{12}\cdot87$	$\bar{7}\cdot32$	III	II	*58*	$\bar{1}\cdot64$	$\bar{1}\cdot88$	0	0
3	$\bar{5}\cdot90$	$\bar{3}\cdot79$	I	0	*59*	$\bar{7}\cdot28$	$\bar{5}\cdot65$	II	I
4	$\bar{2}\cdot46$	$\bar{1}\cdot87$	0	0	*60*	$\bar{4}\cdot73$	$\bar{4}\cdot49$	I	I
5	$\bar{4}\cdot17$	$\bar{4}\cdot24$	I	I	*61*	$\bar{2}\cdot36$	$\bar{4}\cdot51$	0	I
6	$\bar{1}\cdot79$	$\bar{2}\cdot55$	0	0	*62*	$\bar{2}\cdot21$	$\bar{4}\cdot39$	0	I
7	$\bar{1}\cdot19$	$\bar{1}\cdot30$	0	0	*63*	$\bar{1}\cdot02$	$\bar{3}\cdot19$	0	0
8	$\bar{2}\cdot33$	$\bar{2}\cdot07$	0	0	*64*	$\bar{3}\cdot48$	$\bar{4}\cdot47$	0	I
9	$5\cdot42$	$\bar{1}\cdot64$	I	0	*65*	$\bar{2}\cdot11$	$\bar{4}\cdot46$	0	I
10	$\bar{7}\cdot65$	$\bar{4}\cdot50$	II	I	*66*	$\bar{4}\cdot66$	$\bar{6}\cdot06$	I	I
11	$\bar{7}\cdot75$	$\bar{2}\cdot43$	II	0	*67, 68*	$\bar{6}\cdot55$	$\bar{4}\cdot56$	I	I
12	$\bar{4}\cdot29$	$\bar{2}\cdot56$	I	0	*69*	$\bar{2}\cdot26$	$\bar{2}\cdot04$	0	0
13	$\overline{44}\cdot88$	$\overline{146}\cdot66$	VII	VII	*70*	$\bar{7}\cdot06$	$\overline{16}\cdot75$	II	V
14	$\bar{3}\cdot83$	$\bar{3}\cdot18$	0	0	*71, 76*	$\overline{10}\cdot48$	$\bar{5}\cdot38$	III	I
15	$\bar{4}\cdot63$	$\bar{8}\cdot84$	I	II	*72*	$\bar{3}\cdot57$	$\bar{2}\cdot52$	0	0
16	$\bar{2}\cdot58$	$\bar{2}\cdot06$	0	0	*73*	$\bar{1}\cdot32$	$\bar{1}\cdot25$	0	0
17	$\bar{1}\cdot94$	$\bar{2}\cdot97$	0	0	*74*	$\bar{3}\cdot37$	$\bar{6}\cdot91$	0	I
18	$\bar{5}\cdot65$	$\bar{7}\cdot84$	I	II	*75*	$\bar{1}\cdot62$	$\bar{3}\cdot48$	0	0
19, 20, 22	$\bar{1}\cdot54$	$\bar{2}\cdot62$	0	0	*77*	$\bar{7}\cdot43$	$\bar{6}\cdot76$	II	I
21	$\bar{1}\cdot09$	$\bar{2}\cdot95$	0	0	*78*	$\bar{2}\cdot64$	$\bar{1}\cdot13$	0	0
23, 30	$\bar{8}\cdot40$	$\bar{2}\cdot04$	II	0	*79*	$\bar{2}\cdot50$	$\bar{2}\cdot97$	0	0
24	$\bar{8}\cdot01$	$\overline{13}\cdot17$	II	IV	*80*	$\bar{5}\cdot08$	$\overline{10}\cdot45$	I	III
25	$\bar{3}\cdot60$	$\bar{1}\cdot15$	0	0	*81*	$\bar{1}\cdot10$	$\bar{1}\cdot18$	0	0
26	$\bar{3}\cdot88$	$\bar{8}\cdot19$	0	II	*82*	$\bar{1}\cdot17$	$\bar{1}\cdot03$	0	0
27	$\bar{1}\cdot14$	$\bar{9}\cdot77$	0	II	*83*	$\bar{2}\cdot03$	$\bar{4}\cdot39$	0	I
28	$\bar{9}\cdot05$	$\bar{5}\cdot89$	II	I	*84*	$\bar{4}\cdot46$	$\bar{4}\cdot18$	I	I
29	$\bar{1}\cdot13$	$\bar{2}\cdot40$	0	0	*85*	$\bar{4}\cdot55$	$\bar{6}\cdot84$	I	I
31	$\bar{5}\cdot09$	$\bar{1}\cdot95$	I	0	*86*	$\bar{1}\cdot54$	$\bar{3}\cdot46$	0	0
32, 33	$\bar{3}\cdot61$	$\bar{2}\cdot06$	0	0	*87*	$\bar{3}\cdot55$	$\bar{7}\cdot86$	0	II
34	$3\cdot02$	$\bar{1}\cdot48$	0	0	*88*	$\overline{14}\cdot73$	$\bar{7}\cdot64$	IV	II
35	$\bar{1}\cdot52$	$\bar{1}\cdot89$	0	0	*89*	$\bar{3}\cdot54$	$\bar{1}\cdot34$	0	0
36	$\bar{1}\cdot36$	$\bar{8}\cdot32$	0	II	*90*	$\bar{3}\cdot72$	$\bar{8}\cdot52$	0	II
37	$\bar{7}\cdot09$	$\bar{8}\cdot67$	II	II	*91*	$\overline{14}\cdot45$	$\overline{12}\cdot61$	IV	III
38	$\bar{5}\cdot16$	$\bar{3}\cdot20$	I	0	*92*	$\bar{2}\cdot52$	$\bar{3}\cdot92$	0	0
39	$\bar{1}\cdot35$	$\bar{2}\cdot33$	0	0	*93, 94*	$\bar{6}\cdot75$	$\bar{8}\cdot16$	I	II
40	$\bar{5}\cdot26$	$\bar{4}\cdot49$	I	I	*95*	$\overline{10}\cdot65$	$\bar{3}\cdot23$	III	0
41	$\bar{5}\cdot06$	$\bar{3}\cdot01$	I	0	*96*	$\bar{7}\cdot56$	$6\cdot86$	II	I
42	$\bar{7}\cdot01$	$\bar{7}\cdot69$	II	II	*97*	$\overline{17}\cdot15$	$\overline{10}\cdot85$	V	III
43	$\bar{1}\cdot05$	$\bar{3}\cdot62$	0	0	*98*	$\bar{3}\cdot10$	$\bar{2}\cdot77$	0	0
44	$\bar{3}\cdot78$	$\bar{1}\cdot08$	0	0	*99*	$\overline{14}\cdot78$	$\overline{15}\cdot76$	IV	IV
45	$\bar{5}\cdot51$	$\bar{4}\cdot92$	I	I	*100*	$\overline{11}\cdot10$	$\overline{19}\cdot11$	III	VI
46	$\bar{2}\cdot03$	$\bar{6}\cdot95$	0	I	*101*	$\bar{5}\cdot83$	$\bar{3}\cdot98$	I	0
47	$\bar{2}\cdot06$	$\overline{15}\cdot87$	0	IV	*102*	$\overline{15}\cdot65$	$\bar{4}\cdot99$	IV	I
48	$4\cdot72$	$\bar{2}\cdot00$	I	0	*103*	$\bar{2}\cdot56$	$\bar{4}\cdot93$	0	I
49	$\bar{6}\cdot01$	$\bar{8}\cdot06$	I	II	*104*	$\bar{5}\cdot17$	$\bar{1}\cdot12$	I	0
50	$\bar{3}\cdot18$	$\bar{1}\cdot89$	0	0	*105*	$\bar{7}\cdot91$	$\overline{12}\cdot67$	II	III
51	$\bar{3}\cdot80$	$\bar{3}\cdot14$	0	0	*106*	$\bar{3}\cdot47$	$\bar{4}\cdot45$	0	I
52	$\bar{7}\cdot34$	$\overline{16}\cdot33$	II	V	*107*	$\bar{2}\cdot23$	$\bar{3}\cdot88$	0	0
53	$\bar{3}\cdot02$	$\bar{5}\cdot48$	0	I	*108*	$\bar{3}\cdot87$	$\bar{3}\cdot79$	0	0
54	$\bar{1}\cdot02$	$\bar{4}\cdot73$	0	I	*109*	$\bar{2}\cdot23$	$\bar{5}\cdot88$	0	I
55, 56	$\bar{4}\cdot63$	$\bar{6}\cdot53$	I	I	*110*	$\bar{2}\cdot31$	$\bar{5}\cdot62$	0	I

Scale of Divergency classes is given on the Divergency Maps (Maps XLIII. *et seq.*).

TABLE XXII.

Divergency in Eye Colour. Districts.

Number of District	χ^2		Class		Number of District	χ^2		Class	
	Boys	Girls	Boys	Girls		Boys	Girls	Boys	Girls
1	7·8	2·3	0	0	*57*	58·2	55·6	III	III
2	189·7	76·2	VII	V	*58*	7·3	3·5	0	0
3	18·7	24·2	I	I	*59*	49·2	17·8	III	0
4	5·2	22·2	0	I	*60*	21·5	20·9	I	I
5	10·9	7·7	0	0	*61*	37·8	34·5	II	II
6	63·4	51·7	IV	III	*62*	19·8	21·8	I	I
7	25·9	11·3	I	0	*63*	13·9	4·4	0	0
8	43·3	21·9	II	I	*64*	35·0	38·2	II	II
9	40·9	32·2	II	I	*65*	38·8	23·2	II	I
10	18·4	6·0	I	0	*66*	40·3	53·2	II	III
11	31·6	44·5	I	II	*67, 68*	44·2	38·4	II	II
12	37·9	45·7	II	II	*69*	22·4	15·3	I	0
13	270·0	198·5	VII	VII	*70*	39·0	60·5	II	III
14	7·3	3·7	0	0	*71, 76*	25·8	23·3	I	I
15	42·6	30·7	II	I	*72*	7·0	9·5	0	0
16	19·4	27·9	I	I	*73*	5·7	21·3	0	I
17	10·2	18·2	0	0	*74*	2·4	14·2	0	0
18	10·9	17·4	0	0	*75*	11·9	7·7	0	0
19, 20, 22	29·1	47·2	I	II	*77*	32·3	16·2	I	0
21	4·9	17·0	0	0	*78*	23·5	25·0	I	I
23, 30	56·5	42·5	III	II	*79*	28·4	25·7	I	I
24	5·9	3·6	0	0	*80*	53·4	57·9	III	III
25	13·1	9·8	0	0	*81*	18·9	14·6	I	0
26	19·5	29·9	I	I	*82*	13·4	6·6	0	0
27	17·3	14·4	0	0	*83*	49·1	16·0	III	0
28	32·9	45·4	I	II	*84*	20·4	9·4	I	0
29	56·0	45·9	III	II	*85*	36·0	51·9	II	III
31	9·2	4·5	0	0	*86*	9·2	30·1	0	I
32, 33	24·3	42·1	I	II	*87*	12·6	15·6	0	0
34	12·9	20·3	0	I	*88*	107·4	74·8	VI	IV
35	52·4	25·1	III	I	*89*	18·8	13·7	I	0
36	17·8	26·6	0	I	*90*	83·6	13·4	V	0
37	12·6	7·3	0	0	*91*	55·5	60·2	III	III
38	9·3	8·4	0	0	*92*	21·0	15·0	I	0
39	56·7	17·1	III	0	*93, 94*	124·8	112·3	VII	VII
40	45·0	21·6	II	I	*95*	7·5	1·7	0	0
41	8·0	8·2	0	0	*96*	43·7	59·7	II	III
42	17·7	15·0	0	0	*97*	25·0	·7	I	0
43	27·7	16·2	I	0	*98*	1·6	7·1	0	0
44	40·6	20·4	II	I	*99*	24·8	39·0	I	II
45	80·2	85·1	V	V	*100*	15·7	6·3	0	0
46	9·1	1·8	0	0	*101*	24·7	13·8	I	0
47	44·4	23·5	II	I	*102*	79·1	35·2	V	II
48	44·2	12·9	II	0	*103*	24·4	4·1	I	0
49	42·2	39·9	II	II	*104*	15·3	12·2	0	0
50	13·3	23·0	0	I	*105*	31·7	26·2	I	I
51	12·5	17·6	0	0	*106*	35·9	47·8	II	III
52	10·6	26·0	0	I	*107*	10·7	34·5	0	II
53	7·0	11·4	0	0	*108*	50·2	47·8	III	III
54	13·9	6·0	0	0	*109*	35·5	28·9	II	I
55, 56	6·2	19·5	0	I	*110*	144·0	102·0	VII	VI

TABLE XXIII.

Counties considered	Persons per Square Mile
Average Density of Population in non-divergent counties (Boys) ...	291
" " " " (Girls) ...	263
Average Density of Population, taking the 33 counties of Scotland ...	256

sample of the whole country. If, however, there were special causes leading persons belonging to one or more of the colour classes to congregate in certain areas to the exclusion of others, the groups in the densely populated areas would tend to diverge from the form of distribution found to hold for the whole country. The densely populated counties of Forfar, Fife, Stirling, Dumbarton and Lanark (excluding Glasgow), are fair samples of the boy population, and therefore in these densely populated areas no special causes are likely to be found to exist tending to change the distribution of hair colour. The same can be said of the girl populations of Forfar, Stirling and Dumbarton. But the still denser centres, namely the great cities, are different, excepting Edinburgh, which is quite like the general population, for both boys and girls. The cities of Aberdeen, Dundee and particularly Glasgow, densely populated centres, diverge largely from the general population, for some reason or other. What special cause or causes are in operation which make the chief cities, excepting Edinburgh, unrepresentative? Two suggest themselves. (1) One would expect great seaports to differ if foreigners and others (Irish, etc.) of non-Scottish origin, who on an average differed in their colour characters from the general Scottish distribution, settled in these places. (2) Another special cause would clearly exist in the case where a country population contiguous to a large town differed largely from the general population, their influx thereby changing the character of the town population—a population which otherwise should be a fair representation of the whole country. It will be seen in a later section that the facts support the foregoing propositions at least in the special case of Greater Glasgow, which contains within its bounds one-fifth of the whole population of Scotland.

(γ) Divergency in hair colour in district groups will now be briefly considered. It has just been stated that of the great cities Glasgow stands out as by far the most divergent, Aberdeen, Dundee and Leith following, while Edinburgh is quite passably a sample of the general population and is thus for hair colour a representative sample of all parts of Scotland. Kirkcaldy, Perth, Inverness, Ayr, Kilmarnock, Montrose, Stirling, and other smaller towns moderately resemble the general population. Examining now the country districts, it is seen that by far the most divergent area is along the seaboard of the west (see Maps XLVII. and XLVIII.). This area contributes largely to the divergency of the north-west by its blackness, darkness and fairness, as revealed by the division and county analyses, and has the following boundaries. It commences in the north-west of Ross, is bounded by Strath Glass eastward, includes Skye in the west and terminates in Islay and Jura for boys and Mull for girls. This is of course the heart of the Gaelic speaking region. The region of the Caledonian Canal is less divergent than the west, but passing over to Perthshire, East Inverness due again to excess of fair and jet black, and Moray due to fair, the divergency increases. The divergency of the population eastward of this diminishes but it is still high in Donside in Aberdeenshire. Travelling southwards, it again reaches a maximum in the region of Dunkeld and eastward towards the coast, but excluding it, due again to blackness and fairness. As already pointed out in the county groups, the east coast is not very divergent, Fife being the most divergent portion of the coast-line. The region around Dunfermline, due to a large excess of fair, is widely divergent, as also is Midlothian from the same cause. Berwick, north of the Tweed, is a divergent population, but Roxburgh, south of the Tweed, is very like the general population. From Berwick the divergency follows the Tweed and passing through Selkirk and Peebles reaches the Solway Firth, where it again turns in a north-western direction (♀), avoiding Galloway which, as has been already pointed out, passably resembles the general population. The divergency (♀) maintains the same degree in Ayr (north) as in Dumfries, but excepting a portion south of Ayr burgh the whole of the south-west population of boys is fairly homogeneous.

As shown by the district grouping the local populations of boys which passably resemble the general population, are the regions of West Caithness, the south coast of the Moray Firth, excepting Elgin, the Deveron Valley, the Ythan valley, Deeside, Kincardineshire, the south-west of the Firth of Forth, the south-east of Fife, the Lothians, the Teviot valley and the south-west of Scotland—that is, west of Peebles and Dumfries, and south of Renfrew and North Lanark. Speaking generally of the boy population, the populous area commencing in the north-east and ending in the region of Glasgow, i.e. in the northern portion of the south-west (including most of the intervening area), is the least divergent area for boys. The north-west and south-east are the most divergent—the north-west mainly because of its darkness, and the south-east mainly because of its fairness.

The divergency of the girl population is different in some respects. Only a small portion of the coast near Inverness is non-divergent instead of the larger tract for boys. The Lothians, a considerable portion of Dumfries, the northern part of Kirkcudbright and Ayr north of the burgh are all more divergent than the boy population and do not passably resemble the general population as the corresponding groups for boys do. The northern portion of Argyll and the southern portion of Inverness are non-divergent girl populations, the corresponding boy populations being much more divergent. On the whole the non-divergent girl groups are more isolated from one another than the boy groups, and the separation of the population (excluding certain towns) diagonally into an east-north-east and midland non-divergent population and a west-north-west and east-south-east divergent one is not so apparent. In a general way one can see that the district groups confirm the results of the county analysis. One can see from the district

TABLE XXIV. *Divergency in Hair Colour.*

Not Significant or Scarcely Significant. Class 0	Probably Significant or Quite Significant. Classes I and II		Widely Divergent. Classes III and upwards	
Division	Division	Divergence is mainly due to excess of	Division	Divergence is mainly due to excess of
East-Midland	North-Eastern (♂)	fair, red	Northern	fair, jet black, dark (♂)
Southern (♂)	West-Midland (♀)	dark, jet black	North-Western	fair, dark, jet black
			South-Eastern	fair, red (♂) medium (♂)
			South-Western	medium, dark
			North-Eastern (♀)	fair, red
			West Midland (♂)	dark, jet black
			Southern (♀)	fair
County	County		County	
Orkney & Shetland (♂) fair	Orkney & Shetland (♀)	fair	Fife (♀)	fair
Aberdeen (♂) red	Aberdeen (♀)	red, jet black	Banff (♀)	fair, red
Kincardine (♂)	Kincardine (♀)	fair	Selkirk (♂)	medium, red
Forfar	Lanark (♀)	fair	Peebles (♂)	medium, red
Fife	Caithness (♂)	fair, jet black	Ross & Cromarty	fair, dark, jet black
Stirling	Kirkcudbright (♂)	red	Inverness	jet black, dark, fair
Dumbarton	Bute (♂)	medium, jet black	Argyll	dark, jet black
Lanark (♀)	Sutherland (♂)	dark, jet black	Perth (♂)	fair, jet black
Wigtown	Elgin	fair	Glasgow	medium, dark
Haddington	Banff (♂)	fair, red	Govan	medium
Caithness (♀)	Aberdeen City	red, dark		
Kirkcudbright (♀)	Dundee	medium, dark, black		
Bute (♀)	Leith	medium		
Sutherland (♀)	Berwick	fair, medium		
Edinburgh City	Roxburgh	fair		
	Dumfries	fair, medium		
	Ayr	fair		
	Selkirk (♀)	medium, red		
	Peebles (♀)	medium, red		
	Perth (♀)	fair, jet black		
District or Area	District or Area		District or Area	
Caithness inland	Banff and Aberdeen Coast		Seaboard on west coast from Sutherland to Mull, bounded by Strath Glass and Caledonian Canal eastwards	dark, jet black (fair slightly)
Lower Spey, Findhorn & Deveron Valleys, except Elgin	The district parallel eastward to the Caledonian Canal (♂)		Caithness Seaboard to Black Isle	fair, dark, jet black
Deeside	Upper Tweeddale, Ettrick and Yarrow region		Upper Spey and Findhorn Valleys	fair
Kincardine coast	Leith		Region South of the Forest of Athol	fair, jet black
Esk Valleys	Hamilton		Donside (♀)	fair
Loch Earn	Dundee		Dunkeld region	fair, black
Falkirk region (♂)	Central Buchan		Dunfermline region	fair
Haddington coast	Stirling		Glasgow	dark, medium
Teviotdale	South Forfar		Greenock	dark
Galloway & Clyde Valley to Ayr Coast (♂)	Loch Leven district			
Galloway & South Ayr (♀)	South-East Fife			
Upper Spey region parallel to Caledonian Canal, eastwards & northern portion of Argyll (♂)	Selkirk			
Towns:—Edinburgh				
Kirkcaldy				
Perth				
Inverness				
Ayr				
Kilmarnock				
Montrose				
Stirling				

maps (XLVII. and XLVIII.) that the denser midland and east coast areas are well mixed samples of the population. Over the whole of Scotland about 60 of the separate district groups are quite representative of the general population, representing a total of 114,482 boys in the boy population of 257,766, or 44·4 per cent., and 97,839 girls in the girl population of 244,389, or 40 per cent.

The results of the divergency analysis for hair colour can now be summarised. Taking large samples of the population (i.e. the divisions) to remove merely local differences and to some extent the effect of unequal density, thus getting a general view, it is seen that the populous East-Midland division is a fair representation of the general population for hair colour of both boys and girls. The Southern division is so for girls only. The fairly populous North-Eastern division diverges mainly because of its fair-haired and red-haired population; the less populous West-Midland division because of its dark population. The other divisions are widely divergent for several reasons. The divergencies of the Northern and North and North-Western divisions are accentuated by their being comparatively small samples separated geographically from the rest of the population, and are not like the rest of the country because of their excessive fairness and darkness.

Taking smaller samples of the population (counties, cities and districts) it is seen that populous counties are fairly representative of the general population; many populous districts also are; but the great cities (excluding Edinburgh which is representative of the population) are divergent. There are elements present in the urban populations which make them unrepresentative of the general population. Certain outlying sparsely populated districts, particularly on the west coast, are also divergent and unrepresentative. The cause or causes of the divergency in the populations affected will be considered in the next section.

III. *Eye Colour.* (*α*) *Divisions.* The Southern and South-Eastern divisions (♂ and ♀) are the most representative of the general population. These populations are passable samples of the general population. Next in order are the North-Eastern, East-Midland and West-Midland divisions. Then follow the Northern—due to excess of blue eyes, and the South-Western—due to excess of medium and dark; and lastly the most divergent of all, the North-Western, whose divergency is also mainly due to the excess of blue eyes. (See Maps XLIX. and L.)

(*β*) *Counties.* Examining the county divergencies it is seen that, in the boy population, and taken in the order of greatest divergency to least divergency, the following counties diverge greatly from the general population owing to excess of blue eyes, namely: Orkney, Shetland, Ross, Cromarty, Inverness, Elgin, Nairn, Aberdeen and Forfar. Ayr in the south greatly diverges owing to excess of both blue and light eyes, and Lanark greatly diverges owing to a large excess of medium eyes. The divergencies in all the foregoing cases are very great. Among the still significantly but less divergent counties are the Lothians and Roxburgh (excess of blue eyes), Dumfries (excess of light and medium), Argyll and Dumbarton perhaps (excess of light eyes). The non-divergent regions are somewhat isolated from one another; they are Banff and Kincardine in the north; Perth, Fife, Stirling, Dumbarton, Renfrew and Linlithgow, all contiguous—that is, practically the whole of the Scottish Midlands; Berwick, Peebles and Selkirk, contiguous in the south-east, and finally Kirkcudbright and Wigtown in the south.

The girl population shows on the whole equal divergencies in the northern counties already mentioned, divergencies which are due to excess of blue eyes; in Ayr the divergency is almost entirely due to blue eyes and scarcely any to light eyes as among the boy population. The divergency in Lanark is only just significant and is due to excess of both medium and light eyes. Wigtown and Kirkcudbright are both significantly divergent, due in the case of Wigtown to excess of blue eyes and in the case of Kirkcudbright to excess of light eyes. Galloway therefore differs distinctly in its boy and girl distributions of eye colour. The non-divergent regions or rather the non-significantly divergent regions in the girl population for eye colour are as follows: Caithness and Banff in the north; Perth, Linlithgow, Stirling, North Lanark and Renfrew all contiguous; and Berwick, Selkirk and Peebles also contiguous near the Border.

(γ) *Districts.* Looking at the district results, they confirm the county analysis and also the conclusions arrived at with respect to hair colour. The populous Midlands, namely, North Lanark, Perth, Stirling, Dumbarton, Fife and portions of the east coast (i.e. Forfar and north-east Aberdeenshire, and from Nairn to Caithness) are all comparatively representative of the general population in eye colour. Thus while Glasgow itself is divergent, the great part of the environs is not. Such populous centres as Greenock, Kilmarnock, Falkirk, Ayr, are scarcely significantly divergent. Edinburgh, Dundee and Aberdeen cities are significantly divergent. In Aberdeen it is due to excess of medium, in Dundee to excess of dark and medium and in Edinburgh to excess of dark alone. It is seen, just as in hair colour, that the very sparsely populated regions and the very thickly populated areas are the most divergent. But while all the sparsely populated regions diverge on account of excess of blue eyes, all the very densely populated areas diverge because of excess of light, medium or dark. It is to be expected that Dundee would have a fair proportion, or even excess, of dark eyes, since the country adjacent to the city, namely, Perthshire and Forfarshire, are the only counties in Scotland showing excess of this class. The reason for the excess in Edinburgh is not so apparent, unless the migration from these counties to the capital is greater than from the rest of the country. The foreign population, as will be shown later, is significantly associated in general with dark eyes, but on examining the returns, it has been found that foreigners are not present in Edinburgh in sufficient numbers to affect the distribution of dark eyes in the school population there. With Glasgow or certain districts of the western city, the case is different, as will presently be shown. Forfarshire and Perthshire people are perhaps likely to have migrated to Edinburgh in greater numbers than people from other parts. This would account for the excess. The excess of medium eyes in Glasgow may be partly accounted for by a greater proportion of migrants from Lanarkshire, Dumfries, Peebles, Selkirk and Fife, all counties with a distinct excess of this class.

TABLE XXV.

Divergency in Eye Colour.

Not Significant or Scarcely Significant. Class 0	Probably Significant or Quite Significant. Classes I and II		Widely Divergent. Classes III and upwards	
Division	Division	Due to Excess of	Division	Due to Excess of
South-Eastern	Northern	blue	North-Western	blue
Southern	North-Eastern	medium & blue	South-Western	medium
	East-Midland	dark & blue		
	West-Midland	light		
County	County	Due to Excess of	County	Due to Excess of
Banff	Sutherland	blue, dark	Shetland	blue
Caithness	Aberdeen	blue, medium	Ross & Cromarty	blue
Kincardine	Argyll	light	Inverness	blue
Perth	Dumbarton	light	Elgin & Nairn	blue
Stirling	Midlothian	blue	Forfar	blue & dark
Dumbarton	Roxburgh	blue (and dark)	Lanark (♂)	medium
Govan	Dumfries	light	Ayr	blue & light
Renfrew	Orkney	blue	Glasgow	medium & dark
Linlithgow	Aberdeen City	medium	Leith	light & medium
Selkirk	Dundee City	medium & dark		
Peebles	Edinburgh City	dark		
Berwick				
Kirkcudbright				
Wigtown				
Bute				
Haddington				
Fife				
Kinross & Clackmannan				
District or Area	District or Area		District or Area	Due to Excess of
Environs of Glasgow	Parts of North Lanark and North Ayr		North-East Lanark, Carluke region	blue
Renfrew including Greenock	Midlothian except near Edinburgh		Elgin district	blue
Kilmarnock	South Fife (♀)		Spey Valley	blue
Ayr	Dundee		Black Isle	blue
Parts of North Lanark	Most of Perthshire		Glen Urquhart region	blue
Falkirk area	Edinburgh City		Islay & Jura	light
Environs of Edinburgh	Aberdeen City		Shetland	blue
Fifeshire generally except Loch Leven area	Galloway		Glasgow	medium & dark
North Forfar	Linlithgow area			
Area from Buchan coast to Spey Valley	Skye and the adjacent mainland, north and south			
Dornoch and Tain region	Orkney			
Caithness inland	Remaining environs of Glasgow			
North and South Uist	Irvine			
	Roxburgh			
Mull and adjacent mainland	Outskirts of Perth city			
South Ayrshire	Donside			
Dumfries	Part of Buchan coast			
North Kirkcudbright	Lewis			
South Roxburgh	North Dumbarton			
Peebles				
Berwick				

Whether migrants from these counties partly account for the excess of medium eyes in Glasgow or not, excess of medium eyes is associated with densely populated centres and is accordingly dealt with in the section discussing the relationship between density of population and colour. It should be finally noted that the very sparsely populated regions, all of them having an excess of blue eyes, are inhabited by a people who have been undisturbed by any recent immigrations and who most probably are descendants of a race long resident in the country.

The accompanying table (Table XXV.) gives a synopsis of the results respecting the relative divergency in eye colour, in the divisions, counties and districts respectively.

(8) *Class Segregation. The Nature of the Distribution of Relative Local Differences of each Class considered collectively and interlocally, without reference as to where they occur geographically, and the Degree of Segregation of each Class determined.*

I. *Interlocal Constants.* It has been shown (Section 6) that, in each colour class, differences occur throughout the country in localities (specifically pointed out, in each case, in the section referred to), which are distinctly significant. Positive differences, much in excess of the expected, occur in contiguous areas, indicating a differentiation for each class more or less from the remaining population. That is, the existence of these individual local differences proves that the population is not an evenly distributed one with respect to the colour class or classes under consideration. It is true that many of the differences could quite well occur at random and therefore that many localities resemble the general population with respect to one or more classes. But those larger differences, reckoned significant owing to the great odds against their occurring at random, quite upset the proposition that the distribution of the class over the whole country is a random one. Having indicated the localities where individual significant differences occur (thus proving segregation) and also those where non-significant differences occur, the differences for each class collectively will be considered without reference as to where they occur geographically in order to compare the *degrees* of segregation of the classes. It will then be seen which class has the greatest geographical separation. It is therefore necessary to provide a *measure* of local segregation, that is to say, one must have a single common measure, for each class, of the extent of the deviation from a uniform distribution of persons belonging to the class over the whole country. This measure is easily obtained when it is remembered that the relative local differences are all the local differences reduced to a common scale by dividing each difference by its standard deviation. Since this is the case, if the differences are such as would arise from a uniform distribution of the persons belonging to each class all over the country, these differences as a series would of course form a normal distribution with a mean value $h = 0 \pm \frac{\cdot 67449}{\sqrt{q}}$, and a standard deviation $s = 1 \pm \frac{\cdot 67449}{\sqrt{(2q)}}$, where q is the number of groups (either counties, districts, or units of area) considered. Thus

h and s are interlocal constants. This test of the degree of homogeneity of a class or character in a population scattered over a wide area has already been applied by the writer, the constants for both measurable and non-measurable characters being determined*. If then a population is non-segregated with respect to any class (that is, if persons belonging to the class are well distributed over the country) the interlocal constants h and $(s-1)$ will be both equal to zero within the limits of their probable errors, and the segregation of a class will increase as these constants become greater and greater.

The following table (Table XXVI.) gives the values of the interlocal constants for both the boy and girl populations, the distributions considered being those of the relative local differences arrived at from the county data—that is, with the county as the unit of area. Table XXVII. is one in which the classes are arranged in the order of the significance from lesser to greater segregation.

II. *Significance of the Constants.* These results show how decided the deviations are from purely uniform distributions of the class populations. It is seen that the blue-eyed class and the fair-haired class are both highly separated geographically from the general population. The separation is greater in the case of fair-haired girls than in the boys of the same class. The deviation from a random distribution for boys and girls is of the same order in the other colour classes.

TABLE XXVI.

Interlocal Constants. Colour Segregation.

(This table shows that a grouping of children of the same class occurs no matter what class is selected. The figures show the relative extent of the segregation of the classes.)

h = mean of the series of relative local differences, boys or girls, for each colour class.

s = standard deviation of the series of relative local differences, boys or girls, for each colour class.

s_m = standard deviation, as above (boys).

s_f = standard deviation, as above (girls).

Colour	Boys			Girls			
	h	$(s-1)$	$\frac{s-1}{E_{(s-1)}}$	h	$(s-1)$	$\frac{s-1}{E_{(s-1)}}$	$s_m - s_f$
Fair Hair ...	·45	2·75	34·12	1·14	5·14	63·77	−2·39
Red Hair ...	·18	·69	8·56	·09	·56	6·95	·13
Medium Hair ...	− ·57	2·82	34·86	− ·81	2·90	35·98	− ·09
Dark Hair ...	− ·04	2·24	27·79	− ·39	2·95	36·60	− ·71
Jet Black Hair ...	·20	1·36	16·87	·32	1·93	23·95	− ·57
Blue Eyes ...	1·17	5·02	62·28	1·02	4·12	51·12	·90
Light Eyes ...	− ·09	1·78	22·08	·13	1·85	22·95	− ·07
Medium Eyes ...	− ·51	2·09	25·93	− ·59	2·15	26·68	− ·06
Dark Eyes ...	− ·33	2·11	26·18	− ·35	1·87	23·20	·24

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* *Biometrika*, Vol. v. pp. 323—327.

Red hair is the only class which shows a moderate approach to uniformity of distribution, but even in this class the deviations are 7 and 8½ times their probable errors for boys and girls respectively. There is, however, a decided approach towards an even distribution of this class over the whole country compared with all the other classes. But for the probably significant excesses in the north-east of Scotland and the neighbourhood of Edinburgh as shown in the class analysis (Section 6), the distribution of the class of red-haired persons would be fairly uniform. The chance against meeting a schoolboy of this class in travelling over Scotland is about 17 to 1. One would have to note at random the colour characters of at least 18 people on an average in order to have one of this class in the group. But the chances are slightly lower in Aberdeen and Banff and Midlothian. They fall to about 14 to 1 against. The chance against meeting a person of the jet black class is much smaller, about 99 to 1, but the chances vary more as one moves from place to place. In certain places it is as small as 400 to 1. The chance against meeting a person of the dark class or of the fair class is about 3 to 1 and of the medium class about 3 to 2 and so on. The point is that while one can state in a general way the chances for or against a Scottish child belonging to any one of the hair and eye colour classes, these chances vary largely from district to district. The question may be asked, What is the typical Scotchman like? One cannot answer that question offhand from the present data, which deals with school children only. It must be remembered that there is a change in hair colour and eye colour in passing from childhood to manhood. Hair colour generally becomes darker more or less with age. A fair-haired boy or girl may or may not become a fair-haired man or woman, but there is a tendency to become darker. A measure of the change, from Prussian and British data by Pearson*, and by the author† from the Aberdeenshire data, shows

TABLE XXVII.

Segregation in Colour.

(This table shows that children with red hair are the most uniformly distributed class, while fair haired blue eyed children are not well distributed throughout the country. They have a tendency to occur in groups and show therefore the greatest segregation.)

Divergence from homogeneity is	Interlocal constant is	Class of Category
Significant ...	between 0 and 1·0	Red Hair ♂ and ♀
Very significant ...	„ 1·0 and 2·0	Jet Black Hair ♂ and ♀ Light Eyes ♂ ♀ Dark Eyes ♀
Highly significant ...	„ 2·0 and 3·0	Dark Eyes ♂ Medium Eyes ♂ ♀ Dark Hair ♂ and ♀ Fair Hair ♂ Medium Hair ♂ ♀
Excessively great ...	above 3·0	Fair Hair ♀ Blue Eyes ♂ ♀

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* Pearson: *Biometrika*, Vol. III. p. 161.

† *Biometrika*, Vol. V. pp. 339—341.

that the correlation between age and hair colour is quite appreciable. On the assumption that the rate of change of hair colour and eye colour with age is not likely to vary appreciably in passing from one district to another, the author determined the probable distribution of the colour of the adult population of Scotland. The result was published in the same memoir*. Using the result together with the percentage results for the whole of Scotland for boys and girls as found from the present data, the following table (Table XXVIII.), constructed as a probability table, gives the chance of a person of Scottish nationality possessing any one of the following characteristics:—

TABLE XXVIII.

The Probability of the Person belonging to any one of the following Colour Classes is

Colour	Adult Population	Boys			Girls		
		Scotland Generally	Range in Counties		Scotland Generally	Range in Counties	
			From	To		From	To
Hair:							
Fair ...	·115	·250	·221	·314	·274	·243	·344
Red ...	·042	·055	·046	·069	·051	·041	·068
Medium ...	·559	·433	·373	·495	·409	·356	·474
Dark } ...	·284	·250	·187	·308	·254	·194	·291
Jet Black }		·013	·008	·024	·012	·002	·026
Eyes:							
Blue } ...	·278	·147	·103	·259	·148	·118	·252
Light }		·303	·227	·337	·303	·241	·348
Medium ...	·459	·327	·279	·344	·321	·266	·358
Dark ...	·263	·223	·174	·244	·228	·159	·263

With regard to the juvenile population, the above table shows that one can hardly say any particular eye colour is typical of Scotland. There is a bias in favour of light and medium eyes. Brown hair is the most likely colour for a child to possess. Fair and dark are equally likely hair colours in the juvenile population. Medium eyes and brown or medium hair are more typical of the adult population.

Summarising the results of this section, it has been found possible to classify the degrees of segregation of the colour classes—a segregation already proved, although its amount was not revealed in any one case in considering the individual differences. It has now been shown that segregation of certain classes from others exists. The greatest segregation from others (or congregation as a class) is shown in the case of blue eyes, the interlocal or segregation constants $(s-1)$ being 5·02 and 4·12 respectively (see also Diagrams VI. and XV.). The odds against an even distribution of persons belonging to this class is thus enormously great, as also are the odds against persons of the fair-haired class being evenly distributed (see Diagrams I. and X.). The difference in the segregation of the boys and girls is marked. Medium hair and dark hair are approximately equal to fair hair (♂) in their divergence from uniformity of distribution (Diagrams III., IV., XII. and XIII.), and then follow medium and dark eyes (Diagrams VIII., IX., XVII. and XVIII.), and with slightly less segregation still, light eyes (Diagrams VII. and XVI.), and jet black hair (Diagrams V. and XIV.). Finally, in the case of red hair the interlocal constant shows persons belonging to this class to be the most evenly distributed one throughout the country (Diagrams II. and XI.). In no case, however, can the exact probability of an individual belonging to any particular class be predicted with accuracy, just on account of the uneven nature of the distribution of persons belonging to the class. It falls finally to be noted here that the differences for each class have been considered collectively, without reference as to *where* they occur geographically or as to whether the differences for boys and girls occur together in the same place. This point is specially dealt with in another section, where a measure is given of the agreement of the sexes in colour characters.

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* Tocher: *Biometrika*, Vol. v. pp. 339—341.

The most striking result in this section is that bearing on red hair. Its distribution is so markedly different from the rest of the classes as to attract attention. The occurrence of red hair in Scotland either (α) is independent of race, or (β) is one of the effects of blending of races—perhaps widely divergent races, or (γ) is an abnormal condition in hair colour and deserves the attention of the physiologist and pathologist.

(9) *Peculiarities in the Distribution of Colour in Scotland.*

I. *General.* An examination of Table XXIX. will show how far the distribution for boys and girls differ, and also what excesses for hair colour and eye colour occur together. It should be noted that this does not necessarily mean that a particular combination (e.g. fair hair and blue eyes) is in excess. This can be accurately determined only by comparing the excess frequencies of the particular combinations found in the localities under consideration with the proportional frequencies of the same combinations in the general population. The statistical labour involved in such an analysis would be very great and could not be attempted by the writer until the present analysis had been completed. Besides, no funds were available to defray the considerable additional expense which would have been incurred in providing for clerical assistance in tabling the combinations and otherwise completing the statistical analysis. Thus, the results of the present investigation are those flowing from individual classes and only indirectly from combinations.

The table (Table XXIX.) shows that in the girl population of the entire north, excess of blue eyes and fair, dark and black hair occurs together. Excess of blue eyes, although common to the entire north for the boy population, is associated with great excess of fair hair only in the North-Western division, and with excess of red hair in the North-Eastern division, which excess is also characteristic of the girl population in that division. The characteristic feature of the East-Midland division is that it possesses both an excess of blue eyes and an excess of dark eyes. There is an excess of fair hair (♀), and a defect of red hair (♂), but otherwise the hair distribution does not markedly differ from the general population. The West-Midland population differs quite sensibly from the East-Midland. The characteristic feature of the West-Midland population is that excess of light eyes occurs with excess of both dark and jet black hair. The South-Western division with its dense urban populations is quite different from the Southern and South-Eastern divisions. The South-Western population has an excess of medium hair occurring with excesses of medium and dark eyes, while the remaining Southern population is characterised by an excess of fair hair only. The Southern division (♀) has the excess of fair hair occurring with excess of light eyes.

TABLE XXIX.

Excess positive Frequencies peculiar to each of the eight great Divisions of Scotland.*

B = Boy Population. G = Girl Population.

Colour	Division							
	I	II	III	IV	V	VI	VII	VIII
Hair:								
Fair ...	BG	BG	BG	G	—	—	BG	BG
Red ...	—	—	BG	—	—	—	B	—
Medium ...	—	—	—	B	—	BG	B	—
Dark ...	B	BG	—	—	BG	G	—	—
Jet Black ...	BG	BG	—	—	BG	—	—	—
Eyes:								
Blue ...	BG	BG	BG	B	—	—	—	B
Light ...	—	—	—	—	BG	B	BG	BG
Medium ...	—	—	BG	—	—	BG	—	—
Dark ...	—	—	—	BG	—	BG	—	—

The question may well be asked: What can one learn from all this maze of detail as to the significant differences in the distributions of the various colour classes? Are they racial differences or differences due to other factors? One cannot in this memoir enter into a general discussion as to the origin and racial characteristics of the Scottish people. This memoir is concerned only in elucidating the nature of the colour characteristics of Scottish children for the purpose of assisting those engaged in studying racial and social problems and problems in heredity. Such peculiarities as may assist this study may therefore be noticed in detail.

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* In some cases the excess positive frequencies are not quite significant (see tables of relative differences, Table VII.).

II. *Red Hair.* A striking peculiarity in the distribution of red hair has already been noted in the last section. The class is almost uniformly distributed throughout Scotland. Three probable causes of its occurrence were stated in the section referred to. Whether any of these are valid must be determined by investigation, but the fact remains that the distribution of the class widely differs from the distributions of the other classes.

The occurrence of red hair is certainly not confined to modern times, neither is it peculiar to any social circle. It has occurred in the past as a becoming feature in princes and among the people. It is an inherited trait in many distinguished families. Is it that here one has a case of exclusive inheritance, and therefore that cases of red hair occurring in families none of the parents of which belong to the class, are reversions? Such observations as have been made point to this conclusion, but a larger mass of data is wanted to prove or disprove this view.

It is a curious circumstance that significant excess of the class should be found occurring in the historic home of the opponents of Agricola. The solitary reference of Tacitus to the red-haired Caledonians who inhabited Scotland north of the Grampians deserves a passing notice. Taking the general impression of Tacitus as indicated in his statement "Namque rutilae Caledoniam habitantiam comae, magni artus, germanicam originem asseverunt" to mean that the northern Scottish people in his time were mostly red-haired in our sense and appeared to have a North European origin, it is perfectly obvious that the North of Scotland has changed most markedly, as one should expect it would have, in the long interval between his time and the present day. Not more than 5·49 per cent. and 5·09 per cent. respectively of the boy and girl populations of Scotland are red-haired. It is curious to note, however, that the greatest excess of red hair from this proportion *is found* in the region of Scotland north of the Grampians. While this is the case one must remember that the actual proportion of red-haired persons anywhere in the north is really a small one. Only a small proportion, ranging from 5 to 7 per cent., taking fairly large areas, is at the present day red-haired. But if the observation of Tacitus has any truth in it at all, is it fair to infer, since hair colour is an inherited character, that this small class has for a considerable portion of its ancestry the race found in North Britain in later Roman times? One must not come to the hasty conclusion that there was in reality an exclusively red-haired race in Scotland or anywhere else. Indeed, no such exclusive race now exists. But at the present time one finds red hair occurring in all the North European races more or less. That is to say, the

English, Irish, French, German, Danish, Dutch, Belgian, Norwegian and Swedish speaking peoples, at least, have all of them certain proportions of the red-haired class in their respective populations. It thus appears that in every Northern race there is likely to be a certain proportion of the red-haired class. A moderate proportion (5 per cent.) is found in Scotland generally, and all one can meantime say therefore is that it is a characteristic of one-seventeenth of the population of the north-east of Scotland to have red hair; or *that that population, observed in early time to have red hair, has a significant excess of that class over the general proportion found in the country at the present time.*

III. *Relationship between Gaelic speaking Population and Pigmentation.* As already indicated, one cannot open a discussion as to the origin, distribution and characteristics of the Keltic and non-Keltic portions of the population. Nothing germane to this investigation would be solved by it. Authorities differ greatly as to the facts. One could by an analysis of the colour characters of the population with respect to surnames, Highland, Lowland and otherwise, throw a little light on that portion of the Keltic problem bearing on colour. This has already been done by the writer for the populations of Aberdeenshire of 1696 and 1896[*], and he proposes at some future time to table the data now collected for the whole of Scotland in a similar way. What can be done, however, is to investigate the characters of the Gaelic speaking portion of the population as compared with the non-Gaelic speaking and greater portion, and note whether they are really different or not. Here one is on safe ground. The problem of the ethnic descent of the Gaelic speaking and non-Gaelic speaking portions of the population the writer leaves untouched. But he proposes to note whether there is any particular association of colour with the Gaelic speaking population. In the Report on the Scottish Census of 1901[†], the number of "Gaelic and English" speaking persons above three years of age is given for each division of Scotland. The percentages of Gaelic and English speaking persons in the eight divisions of Scotland can thus be found and compared with the corresponding percentages for hair colour and eye colour found from the results of this survey. The correlation coefficients were determined in the following manner:—Let x_1 = deviation from mean percentage of the Gaelic speaking population; x_2 = corresponding deviation from the mean percentage of children belonging to any colour class; σ_1 = standard deviation of percentage of the Gaelic speaking population; σ_2 = standard deviation of the percentage of children belonging to colour class s; and N = number of the divisions into which Scotland is divided; then the correlation coefficient is:

$$r = \frac{\Sigma x_1 x_2}{N\sigma_1\sigma_2},$$

and determines the degree of association or correlation between the Gaelic speaking population and the colour class s. Taking as an example s = jet black hair, the following table (Table XXX.) was formed:—

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[*] *British Association Report*, Cambridge, 1904, p. 707.

[†] *Eleventh Decennial Census of the Population of Scotland with Report*, Vol. I. Table XV. p. xxviii.

TABLE XXX.

Division		Gaelic speaking Population x_1	Jet Black Hair x_2
I.	N.	4·82	·30
II.	NW.	39·17	·79
III.	NE.	– 9·30	– ·25
IV.	EM.	– 8·35	– ·10
V.	WM.	1·73	·08
VI.	SW.	– 8·57	– ·20
VII.	SE.	– 9·35	– ·38
VIII.	S.	– 10·15	– ·22

An inspection of this table reveals the fact that in *every* division where there is an excess of the Gaelic speaking population there is an excess of the jet black class, and *vice versâ*. The values of the correlation coefficient r and its probable error in the particular case when $r = 0$, or $E_{(r=0)}$, have been evaluated for all the colour classes and the Gaelic speaking population with the following result (Table XXXI.). The ratio $r/E_{(r=0)}$ shows how much the correlation found exceeds the probable error when r is equal to zero.

TABLE XXXI.

Correlation of Hair and Eye Colours with Gaelic speaking population.

Colour Class	r	$\frac{r}{E_{(r=0)}}$
Fair Hair ...	·3482	1·37
Red Hair ...	– ·3027	– 1·19
Medium Hair ...	– ·8663	– 3·40
Dark Hair ...	·8126	3·19
Jet Black Hair ...	·9581	3·76
Blue Eyes ...	·8663	3·40
Light Eyes ...	– ·1248	– 0·49
Medium Eyes ...	– ·8760	– 3·44
Dark Eyes ...	– ·6387	– 2·51

This result is of some importance. It shows definitely for the first time the general nature of the colour characters of the Gaelic speaking as against the non-Gaelic speaking population of Scotland. It proves that the proportion of dark-haired and jet black-haired persons is far greater among the Gaelic speaking than among the non-Gaelic speaking population. In technical language, dark hair and jet black hair are positively correlated to the Gaelic speaking population. The association is clear, and the result ought to be of assistance to the student of the Keltic race. The above table also shows that blue eyes are associated with the Gaelic speaking population, the association being slightly greater than in the case of dark hair, and nearly as great as in the case of jet black hair. The odds against a less correlation than that found are so great as to warrant the conclusion that blue eyes are far more common where Gaelic is spoken than where it is not. Medium eyes are distinctly correlated negatively to the Gaelic speaking population. One may safely conclude that medium eyes are rarer in Gaelic speaking regions than in the rest of the country. Medium hair, and in a lesser degree dark eyes, are also negatively correlated to the Gaelic speaking population, the correlations being appreciable in each case, but fair hair, red hair and light eyes are present in practically the same proportions in both the Gaelic and non-Gaelic speaking populations. Thus, on a direct survey of the Gaelic speaking population, one would expect the group to be much darker in hair colour and more blue eyed persons would be expected among the Gaelic speaking than in the remaining population, the excess being accompanied by lesser proportions of medium hair and medium eyes and also dark eyes. No sensible differences would be expected in the fair-haired, red-haired, and light-eyed classes compared with the general population. The definite relationship between the Gaelic speaking population and certain colour classes now established, enables one to interpret more fully the meaning of the significant differences in the western portion of Scotland. In Table XXX. it is seen that the North-Western, West-Midland and South-Western divisions are the only ones in which there is an excess of Gaelic speaking persons over the general average. In these divisions about 65 per cent. in Sutherland and about 50 per cent. in each of the counties of Ross and Cromarty, Inverness and Argyll speak Gaelic. So far as hair colour is concerned, all these counties show great excess of dark and jet black hair. This excess is therefore due mainly to the Gaelic speaking populations in these counties. Light eyes, although in excess in Argyll, are neither peculiar to the Gaelic speaking population nor to the non-Gaelic speaking population, since the value of the correlation coefficient is a very small one. The one group is likely to have as large a proportion of light eyes as the other. But blue eyes are associated even more intensely with Gaelic speaking people than dark hair, and this class is in excess in Sutherland, Ross and Cromarty, Inverness and the Western Isles. A fairly large proportion of the dark-haired Gaelic speaking people have therefore blue eyes. In these counties, however, fair hair is also in excess, and since the Northern Isles, Orkney and Shetland, are characterised by a large excess of fair hair and blue eyes and by an exceedingly small proportion of Gaelic speaking people, one would infer that blue eyes are largely associated with fair hair in the non-Gaelic portion of the population of these counties as well. Thus these counties consist of a mixture of fair-haired, blue-eyed, or blonde non-Gaelic speaking population (or if Gaelic speaking, at least of non-Keltic origin) and a dark-haired Gaelic speaking population. The distribution of eye colour in this latter population is unknown, but all classes of eyes are most probably represented, a fairly large proportion of blue eyes being quite certain.

IV. *Relationships between Pigmentation, Density of Population, and Foreigners.*

In the Census Report already referred to, the number of persons per square mile is given for each of the eight chief divisions of Scotland*. The means are at hand therefore to compare the density of the population with pigmentation. With regard to the foreign element, one would naturally come to the conclusion without examining the actual data that foreigners are likely to be found in the more densely populated areas of the country. Business leads them to where the industries are and therefore to where closely packed populations reside. It is desirable therefore that any correlation existing between the two should be measured. The association has been measured from two sets of data. The degree of correlation has been determined (1) between foreigners and density (number of persons per square mile), and (2) between foreigners and the number of families (α) living in one and two rooms, (β) living in three to nine rooms, and (γ) living in ten rooms and upwards. The correlation coefficients were calculated from the following table (Table XXXII.):—

TABLE XXXII.

Division	Persons per square mile	Number of families living in (per 1000 of each division)		
		One and two rooms	Three to nine rooms	Ten rooms and upwards
I.	31	535·8	440·4	22·5
II.	23	490·9	468·3	40·6
III.	127	394·3	569·4	36·3
IV.	166	549·8	419·0	31·1
V.	87	552·5	408·6	38·8
VI.	827	686·4	296·2	17·3
VII.	363	530·7	422·1	47·2
VIII.	62	376·9	562·9	60·2

The following table (Table XXXIII.) gives the population, the number of foreigners, and the number per 1000 of the respective populations, of each division in Scotland:—

TABLE XXXIII.

Division	Population	Foreigners	Number of Foreigners per 1000	Deviation from mean per 1000
I.	112175	147	1·3105	−1·6643
II.	166554	124	0·7445	−2·2303
III.	460941	621	1·3472	−1·6276
IV.	665215	1515	2·2775	−0·6973
V.	348585	1044	2·9950	0·0202
VI.	1862775	15062	8·0858	5·1110
VII.	662415	3888	5·8694	2·8946
VIII.	193443	226	1·1683	−1·8065

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* *Eleventh Decennial Census*, Appendix Tables, p. xxxv.

The last column in above table has of course to be compared with each of the values for the various classes of hair colour and eye colour and with the density figures. The values of r, the correlation coefficient, and r/E_r are given in the following tables (Tables XXXIV. and XXXV.):

TABLE XXXIV.

Foreigners and Density.

Correlation between	r	$\frac{r}{E_r}$
Foreigners and Density	·9456	37·46
" and Number of families in 2 rooms and less	·7555	7·38
" and Number of families in 3 to 9 rooms	– ·7793	– 8·32
" and Number of families in 10 rooms and upwards ...	– ·3362	– 1·77

These results are interesting. They show that foreigners tend (1) to reside in most densely populated areas, (2) to reside in districts where families live in one room or two rooms, and (3) not to reside as a rule in districts where families live in three to nine rooms. There is not a very decided tendency against their residing where families live in large houses with many rooms.

The following are the results of the comparison between foreigners, density and pigmentation:

TABLE XXXV.

Correlations between Density of Population, Foreigners and Pigmentation.

Colour	Density		Foreigners	
	r	$\frac{r}{E_{(r=0)}}$	r	$\frac{r}{E_{(r=0)}}$
Hair:				
Fair ...	– ·805	3·16	– ·788	3·09
Red ...	– ·001	·005	– ·093	·37
Medium ...	·716	2·81	·757	2·97
Dark ...	– ·195	·77	– ·243	·95
Jet Black ...	– ·460	1·81	– ·497	1·95
Eyes:				
Blue ...	– ·612	2·40	– ·668	2·62
Light ...	·090	·35	·219	·86
Medium ...	·560	2·19	·523	2·05
Dark ...	·533	2·09	·514	2·02

The striking feature in the above table is the great similarity in the results in comparing foreigners with pigmentation and density with pigmentation. The results show the futility of attempting to draw any conclusions as to the probable predominant colour classes of foreign immigrants from these tables since the correlation between foreigners and density is exceedingly high. It is certainly the case that foreigners coming into this country live in districts in Scotland having on an average distinctly greater proportions of medium haired, medium eyed and dark-eyed persons among their number than that found for the general population. But these are just the classes which are in excess in densely populated parts, and foreign immigrants reside for the most part in these denser centres. One cannot therefore say from the foregoing whether the foreign immigrants have large proportions of these classes among their number or not. It is not known what the proportions are. It has simply been proved that they are associated with densely populated centres in Scotland. The colour characters of the immigrants themselves must be investigated. The effect of the foreign element in the population will be considered in detail in the special section on Glasgow and environs.

The subsection can be summarised as follows:

Foreign Immigrants	on reaching this country tend to reside in	Densely Populated Areas	where (among school children) excesses are found of the following classes, namely:	Medium Hair Medium Eyes Dark Eyes

V. *Relationship between Pigmentation and the Death Rate.* It is stated by Pearson* that there is a positive correlation between fairness and disease in childhood. It has long been known that there is a correlation between density of population and the death rate not due directly or mainly to the crowding of persons together but to the association with density of filth, poverty, drunkenness and the like. Russell has shown the correlation between the size of house and the general death rate†. Newsholme‡ pointed out in 1891 that the true test of density is a statement of the number of persons living in each occupied room. Applying any test of density, the correlation between it and the death rate is high, using Scottish figures. Taking for instance the number of persons per square mile, the correlation

TABLE XXXVI.

Correlation between Density of Population and Death Rate in Scotland.

Division	Deviation from mean number of persons per square mile	Deviation from mean Death Rate
I.	−179·75	−1·240
II.	−187·75	− ·078
III.	− 83·75	−1·012
IV.	− 44·75	·138
V.	−123·75	− ·275
VI.	616·25	2·450
VII.	152·25	·315
VIII.	−148·75	− ·297

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* Pearson: *Biometrika*, Vol. III. p. 465.

† Russell: *Proceedings of Glasgow Philosophical Society*, Nov. 1888.

‡ Newsholme: *Journal of Royal Statistical Society*, Feb. 1891.

was found to be $r = \cdot 9125$ from the accompanying table (Table XXXVI.). Diagram XIX. shows graphically the connection between density and other characteristics in the population.

Thus the association is very high. It will be of interest now to note what relationship, if any, exists between colour and the death rate. The following results were obtained (Table XXXVII.).

TABLE XXXVII.

Correlation between Death Rate and Pigmentation.

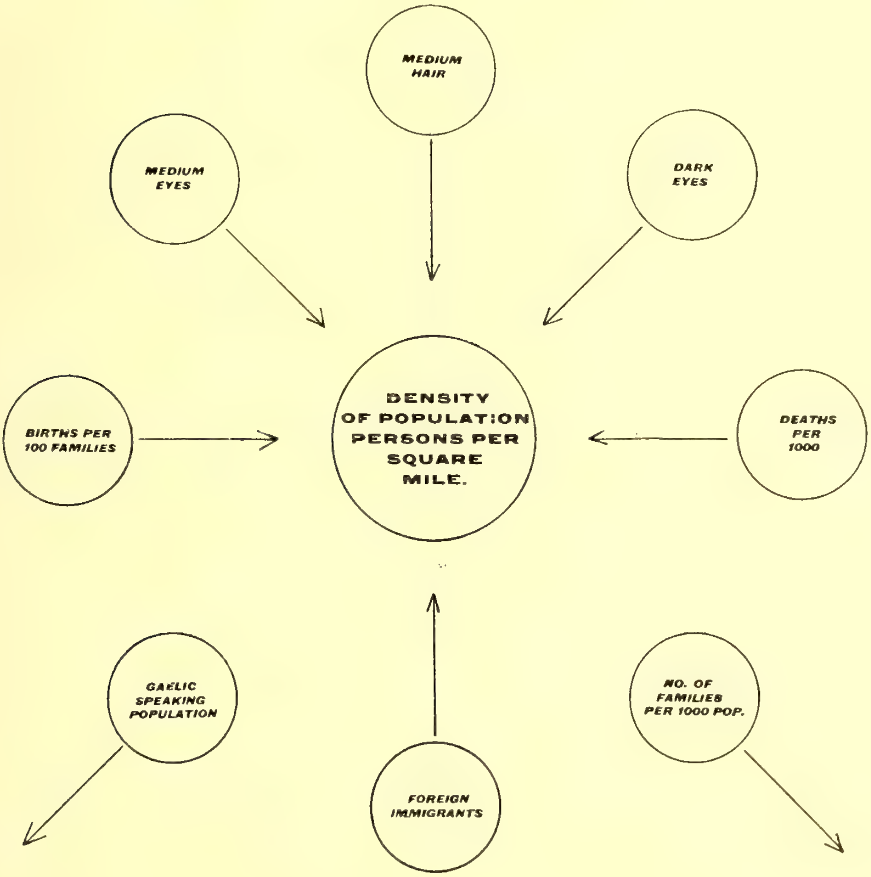
	r	$\frac{r}{E_{(r=0)}}$
Hair:		
Fair ...	−·806	−3·16
Red ...	−·347	−1·36
Medium ...	·567	2·23
Dark ...	·064	·25
Jet Black ...	−·252	−·99
Eyes:		
Blue ...	−·488	−1·91
Light ...	·226	·89
Medium ...	·284	1·11
Dark ...	·410	1·61

This result, a positive correlation between the death rate and medium hair, and another between death rate and dark eyes, was to be expected, since density is similarly associated with colour. The denser the population is the greater is the death rate; the denser the population is the greater is the excess of medium hair; therefore the greater the excess of medium hair, the greater the death rate. (1) Is it to be concluded that medium haired or dark-eyed people are less virile and cannot stand the strain of city life? (2) Must one say that the blue-eyed fair-haired classes have been all killed out in densely populated areas since they have less resistive power and it is now the turn of the darker section of the population who now presumably show greater mortality? (3) Or must it be said that the conditions of town life are such as to cause a larger section of the fair-haired class to become so much more sensibly darker in towns than in rural districts so as to be classed as medium or brown? There is a darkening in the fair-haired class with age; that much is well known. Is the darkening more intensely operative in towns, and why? (4) If not, can any explanation be offered as to why medium hair colour is associated positively with density and thus with the death rate—why a proportion of medium haired persons much above the average live in more densely populated parts (and are thus of the poorer class) where mortality is higher than the average? An attempt will now be made to answer these questions so far as they can be answered, seriatim.

VI. *The probable Cause of the Association of the Medium or Brown Haired Class with Density of Population.* It cannot be said from the data of this survey what colour class is more virile than another or whether there is any difference among the classes. Is such an hypothesis necessary? This question is put, because it can be quite easily seen that if there is a large proportion of the medium class living in very densely populated areas, deaths among medium haired persons will be more frequent there than in the rest of the country. But this does not explain why medium haired persons are in excess in densely populated parts. No reason is known why darkening with age should be more intense in densely populated centres, but it is a possible explanation of the excess of medium in these centres and the hypothesis should be proved or disproved by observation. If there was any special force tending to send medium haired and dark-eyed persons in from the country to towns, that would explain the excess. But no such force is known to exist. If foreign immigrants had a high percentage of medium hair this might be a factor, but foreigners coming into this country are, on an average,

DIAGRAM XIX

Relationship between Density and the other characteristics of the Scottish Population


MEDIUM HAIR
MEDIUM EYES
DARK EYES
BIRTHS PER 100 FAMILIES
DENSITY OF POPULATION PERSONS PER SQUARE MILE.
DEATHS PER 1000
GAELIC SPEAKING POPULATION
NO. OF FAMILIES PER 1000 POP.
FOREIGN IMMIGRANTS

darker-haired* than the Scottish population. With a less proportion of medium hair than that occurring in this country, the foreigners—a handful compared with the total population of towns—could have no effect in this direction. They are likely, from actual observations, to have an effect in *very* densely populated areas in the direction of darkness of hair and dark eyes. If Irishmen and Englishmen were browner-haired on an average than Scotchmen, and if it was proved that a high proportion of them lived in densely populated areas of Scotland, this would be an important factor and a probable explanation. It is true that, at any rate in Glasgow, the Irish are found in large numbers, but from the results of this survey (see Glasgow section—Irish children) and the results given by the pioneer observer of colour in this country, Beddoe†, Irishmen have no greater proportion of the medium class on an average than Scotchmen. Beddoe's statistics for England have also been tabulated and a general percentage evaluated. The English appear on an average to be no browner-haired than the Scot. Both indeed seem likely to have a less proportion of this class. Pearson's statistics for English boys show that they are fairer than Scottish boys. There seems however to be a higher proportion possessing jet black hair.

The following table (Table XXXVIII.) shows the colour distributions of English, Scottish, and Irish populations, as at present known.

TABLE XXXVIII.

	Hair					Eyes			
	Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark
(1) Irish	10·4	4·6	33·4	40·5	11·0	—	66·5	14·7	18·6
(2) English, North of England	21·3	5·8	41·6	28·6	2·6	—	60·5	14·7	24·7
(3) Scottish Adults, Probable Distribution	11·5	4·2	55·9	28·4	—	—	27·8	45·9	26·3
(4) Scottish Boys, Actual Observation	25·0	5·5	43·3	25·0	1·3	14·7	30·3	32·7	22·3
(5) Irish Boys, Glasgow ...	22·1	5·1	35·1	33·1	4·6	21·2	26·0	28·4	24·4
(6) English Boys	33·5	4·1	34·0	26·5	1·9	—	41·5	37·0	21·6

The figures for the Irish and English populations are derived from Beddoe's tables†. The figures for Scottish adults are the author's, deduced from results from the Aberdeenshire adults and Scottish school children‡. The figures for Scottish boys are from the present data; those for Irish children are also from the present data. Pearson's figures are taken from the Fourth Huxley Lecture§. The table is not intended to represent the *actual* distributions for the three kingdoms, but merely to show that the excess of medium hair found in Scotland is not likely to be from Irish or English sources. The presence of neither foreigners, Irishmen, Englishmen, nor of brown-haired immigrants from rural districts at home (although they might contribute a little) can explain the excess of medium hair. None of these groups are likely to have contributed; it has been proved, in short, that they do not. Having considered among others the effect of the presence of persons of a non-Scottish origin—the effect of a section of the population proved to be present whose origin is forth of Scotland—and shown it to be inappreciable or non-operative, one must conclude that the cause has an internal origin and is not derived from an external source. It must be something operating within the Scottish population itself. What factor is operating within Scotland producing an excess in densely populated areas of the various shades of brown hair classed as medium?

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* See actual results in section on Glasgow; also Livi and others on Italians, Jews, Russians, etc.

† Beddoe: *Races of Britain*, pp. 188, 189; and pp. 160 et seq.

‡ *Biometrika*, Vol. v. pp. 341, 342.

§ *Journ. Anthrop. Instit.* Vol. XXXIII. 1903, pp. 214, 215.

One or more of at least three factors might possibly operate and provide the explanation.

(A) *Darkening among the fair-haired might occur earlier in towns and might be more intense.* No grounds exist for this explanation. It is purely hypothetical and requires investigation. (B) The medium class might be the most fertile. Since this class is correlated with density of population, since the lower classes live in the densely populated areas, and since it has been shown that the lower classes are the most fertile, one might conclude that the medium class is the most fertile of the fertile lower classes. If true, this would explain the excess. (C) The excess might be due to the effect of blending of the fair and dark classes of the population.

With regard to (A) until observations from towns and rural districts, bearing on this, are calculated, the truth or otherwise of the hypothesis cannot be verified. The pigmentation survey returns contain no data capable of furnishing the means of testing this hypothesis.

(B) *The probability of the medium haired class being the most fertile.* Comparing the number of births per 100 families (calculated from the figures of the Census Report—the only data at present available to estimate the relative fertility in the various divisions of Scotland) with density of population, the value of the correlation coefficient was found to be

$$r = \cdot 782 \pm \cdot 093\,;\ \text{and}\ \frac{r}{E_r}\ \text{thus} = 8\cdot 44;\ \text{and}\ \frac{r}{E_{(r=0)}} = 3\cdot 08.$$

That is to say, births per family are greater in number in more densely populated areas than in sparsely populated parts*. Of course this does not give the measure of true fertility. To get this, one would require to get a return of the number of wives for each division, whose ages are within the childbearing range, and compare this with the number of births in each division. The value, $r = \cdot 782$, cannot be taken as the true measure unless the ratio of the number of possibly fertile wives to the number of families is quite approximately the same in each division. The correlation, however, between the number of births per family and density of population is so high as to warrant the conclusion that fertility is really greater among the inhabitants of densely populated areas. Since the more densely populated centres are occupied by the lower classes, this is tantamount to saying that the lower classes are more fertile than the remaining section of the population, a conclusion already reached by several observers. Let now the number of births per family, in each division, be compared with the pigmentation data. The following results were obtained:

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* On the other hand on comparing the number of families per 1000 of the population with density of population the correlation was found to be negative ($r = -\cdot 6109 \pm \cdot 1495$). This does not necessarily mean that in towns the families are larger. The large population of young men and women employed in industries and otherwise and drawn from less densely populated areas contribute largely, if not mainly, to the result.

TABLE XXXIX.

Correlation between Pigmentation and Births per Family.

Colour	r	$\frac{r}{E_{(r=0)}}$
Hair:		
Fair ...	− ·936	−3·67
Red ...	− ·043	−0·17
Medium ...	·727	2·85
Dark ...	− ·059	−0·23
Jet Black ...	− ·504	−1·98
Eyes:		
Blue ...	− ·775	−3·04
Light ...	·386	1·51
Medium ...	·671	2·63
Dark ...	·292	1·15

These results show that the number of births per family is greater where there are excesses of medium hair and medium eyes and is much less in regions of excess of fair hair and blue eyes. Now these results are similar to those obtained in comparing density of population with pigmentation except that dark eyes are significantly associated with density, but not with the birth rate per family. Thus the lower class population is associated with a higher birth rate per family and with an excess of medium hair and medium eyes over the general population. Is one to say that the medium haired, medium eyed classes are as a whole more fertile over the whole country; or are only those sections of them living in more densely populated parts (i.e. working class sections of these classes) the more fertile? That question cannot be answered from the present data, but it can be said that the medium haired, medium eyed and populous lower classes are more fertile than the remaining population, and this factor is probably operating in favour of producing distinct excess of these classes in the more densely populated areas of Scotland where they are found.

(C) *The probability that excess of medium hair in dense centres is due to blending.* Consider first a population consisting of more or less isolated groups of fair-haired and dark-haired people living in sparsely populated regions. The chances of conjugal union of persons of the same colour class, if the mating occurs at random or is pangamic, are greater than if they lived all together as one group in a densely populated town. In the past, more unions between persons of the dark-haired class (for instance, in the west coast) were likely, on the assumption that mating occurred purely at random, to occur than between them as a class and the fair-haired class. Similarly, isolated groups of the fair-haired class would have more unions among themselves than with the smaller dark-haired groups. On the other hand, however, wherever towns sprang up, the different classes would be brought more in contact with one another and the chances of union among all classes with one another would be greater. But does mating actually occur purely at random? That is to say, taking the character here considered, hair colour, does the fair-haired class, for instance, select mates indiscriminately from the other classes or do they tend to mate more with members of their own class? Similarly, taking eye colour, what is the nature of the mating? Pearson* has shown that, for certain measurable characters, like tends to mate with like; that is, assortative or homogamic mating exists. For eye colour he has shown that both homogamic and preferential mating exist. Can one say with respect to hair colour whether the mating is homogamic, preferential or pangamic? In the past, with isolated groups and with the clan system in vogue, endogamic mating would certainly exist and be a powerful factor in determining the prevailing colour characters. Thus one would expect at the present day to find a section of the population in the Highlands with characters distinctly different from another section, and this, one finds, is the case. Different race or clan groups have married within the race or clan and retained the ancestral characters. But endogamic mating can now no longer be a powerful factor, except in isolated cases, since greater intermixture and greater dispersal of the population now occur than was ever possible in the past. Retaining this form as possibly contributing, and remembering that mating of unlikes (conjugal union of say a member of the jet black class with a member of the fair-haired class) is also quite possible, the five possible forms emerge, namely:

Homogamic = like with like;
Endogamic = members of the same clan;
Preferential = preference for a certain colour;
Heterogamic = mating of unlikes; and
Pangamic = random.

Now while it has been shown that inheritance of eye colour is more of the exclusive form than of the blended form, is it more likely that hair colour (except perhaps red hair which has been already noticed) is a case of blended rather than of exclusive inheritance? As yet there are no statistics from which the intensity of blending can be directly proved or disproved. One can only advance the theory that blended inheritance prevails largely in hair colour, and see whether it explains the excess of medium hair in densely populated centres. Blended inheritance in hair colour certainly exists, although no statistics are forthcoming to prove its intensity. The average observer will have noticed that the offspring of parents, one fair and one dark, are not uniformly fair and dark, but have also on an average among their number members of the brown-haired or medium class. What the proportions of each are, on an average, will be revealed by observation. What form the distribution takes does not affect the argument. Granted that pangamic mating (not excluding other forms) now exists for hair colour among the Scottish people and granted blended inheritance as probably occurring as one of the results, and the phenomenon of regression will appear in hair colour. The colour of future generations of offspring will tend to become brown-haired and in a few generations a brown type will be established breeding true to itself. Thus in densely populated areas where greater opportunities for random mating exist, a greater proportion of medium hair will arise, granting blending of hair colour as an appreciable factor, but not of course debarring exclusive and even particulate inheritance as operative as well. This alone, or together with the suggested greater fertility of the medium haired class, would explain the excess of medium hair found in densely populated areas particularly in and around Glasgow, an excess which is not explainable by the presence of non-Scottish or Scoto-Keltic elements in the population. As has been said before, it cannot be proved from the present data what is the cause of the excess, and the foregoing is only the probable explanation. The proof or otherwise of the validity of the theory will be forthcoming when the results of direct observations on parents and offspring have been made, tabulated and analysed.

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* Pearson and Lee: *Biometrika*, Vol. II. pp. 357—462; and pp. 481—498; and many others.

VII. *Colour classes which are associated geographically.* (α) *Hair classes which are associated with one another.*—The theory that brown hair is really a blend of fair and dark is supported by the fact that throughout the country excess of the class is not generally associated with excess of other hair colour classes. In order to determine the extent of the association of excesses and otherwise of the various colour classes, the percentages of all the classes were compared with one another and the correlation coefficients determined. The following table (Table XL.) gives the numerical values of the correlations of each class with all the other classes. One must be careful as to the meaning of the result. Association of excesses of fair hair and blue eyes (a positive correlation) does not necessarily mean from this portion of the analysis that the blonde type predominates in the region of excess. All the analysis tells one is that regions of excess of fair hair are also regions of excess of blue eyes. This will be evident when one considers the other associations with fair hair. Examining the table it will be seen that regions of excess of jet black hair are also generally regions of excess of *fair* and *dark.* This combination could not obviously occur in the same person. Regions of excesses of fair and dark indicate the presence of two types—a heterogeneous and not a homogeneous population. On the other hand, examine the column indicating the associations with excess of medium hair. *Excess of medium hair as a rule is associated with excess of no other colour class.* The negative correlations show that regions of excess of medium hair are *not* regions of excess but of defect of dark and jet black hair. This would seem to indicate a greater approach towards fusion of the fair and dark types in more densely populated centres and the consequent gradual disappearance of these types to form the medium (brown or dark brown) type. There is no bias for or against the presence of red as a class with excess of medium hair. *Excess of red hair is found as a rule only in regions where the proportion of the dark-haired class is well below the average.* A slight excess of fair is associated with excess of red. The probable reasons for these positive and negative associations will not be further entered into here. Sufficient evidence has not yet been accumulated to explain the differences with regard to pigment and matrix in human hair*. The present grouping of the shades into five classes is based on the general appearance of hair in the mass. The problem generally is one on inheritance, but the material to solve the problem comes from divers sources, chemical, microscopical, biological, statistical. Until this material is collected and dealt with, no explanation of any great weight from a scientific point of view can be given, particularly as to the shades of red hair, although several quite plausible theories can quite easily be advanced. One must therefore be content to state the bare facts as they emerge from the statistical analysis. It does not appear to be an insoluble although perhaps it is a somewhat difficult problem. When more light is obtained the explanation will be forthcoming.

(β) *Eye classes associated with one another.—Excess of dark eyes in densely populated centres.* The only class which is not positively associated significantly with any other class is the class of light eyes. Excess of light is negatively associated with blue and dark. Where light eyes are in excess, blue and dark eyes are not likely to be so, but the reverse; there is likely to be a defect of these classes. Excess or defect of light eyes is not connected with any excess or defect of medium eyes. Excess of blue eyes is as a rule associated with defects in the frequencies of the other classes of eye colour. Excess of dark eyes accompanies excess of medium and defect of the other two, light and blue. So that, broadly speaking, it is found that excess of blue eyes is found alone, excess of light eyes is found alone and excesses of dark eyes and medium eyes occur together. This is an interesting result, since it has been shown by both Galton and Pearson that exclusive inheritance prevails in the dark-eyed class. That is to say, the offspring for example of parents one dark-eyed and the other light-eyed or blue-eyed are, as a rule, either dark-eyed or light-eyed or blue-eyed. Medium eyes do not usually appear from such unions. There is no evidence as yet as to the blending or otherwise of the three classes, blue, light and medium. But since the offspring of parents, one dark-eyed and the other medium eyed, are likely to be either dark-eyed or medium eyed, unions among the two classes for generations would have no appreciable effect on the eye colour of the offspring, and therefore, as the results of this investigation show, one would still have the two classes, just as though there had been no intermarriages in these classes at all. Pearson* has shown that preferential mating is likely to be operative against the dark-eyed class and he also shows from Galton's data that they are more fertile under their present environment than say the light-eyed. The results of the present analysis do not tend to confirm this (see Table XXXIX.), but it must be remembered that the comparison was not made between births with respect to possibly fertile wives and pigmentation, but between births per family and pigmentation. Thus, with

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* The chemical and microscopical aspects of the problem of hair colour will be dealt with by the author in another memoir.

TABLE XL.

Association of Colour Classes in the same Regions.

Values of r the correlation coefficient.

	Hair					Eyes			
	Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark
Fair ...	1	·3074	– ·6916	– ·0867	·3733	·7207	– ·3044	– ·5786	– ·4233
Red ...	—	1	·0873	– ·5881	– ·3414	·0324	– ·3966	·3858	·0022
Medium ...	—	—	1	– ·6459	– ·9039	– ·9431	·2273	·8563	·6874
Dark ...	—	—	—	1	·8443	·5075	·1166	– ·6295	– ·5110
Jet Black ...	—	—	—	—	1	·8728	– ·2565	– ·8211	– ·5200
Blue ...	—	—	—	—	—	1	– ·4329	– ·8226	– ·5429
Light ...	—	—	—	—	—	—	1	– ·0905	– ·4290
Medium ...	—	—	—	—	—	—	—	1	·6991
Dark ...	—	—	—	—	—	—	—	—	1

TABLE XLI.

Classes, excesses of which are found together in the same regions.

	Hair					Eyes			
	Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark
Hair:									
Fair ...	—	+	—	—	+	+	—	—	—
Red ...	+	—	—	—	—	—	—	+	—
Medium ...	—	—	—	—	—	—	—	+	+
Dark ...	—	—	—	—	+	+	—	—	—
Jet Black ...	+	—	—	+	—	+	—	—	—
Eyes:									
Blue ...	+	—	—	+	+	—	—	—	—
Light ...	—	—	—	—	—	—	—	—	—
Medium ...	—	+	+	—	—	—	—	—	+
Dark ...	—	—	+	—	—	—	—	+	—

The rows or columns show for any one class what other classes are associated with it.

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* Pearson: *Phil. Trans.* Vol. 195, pp. 79—150; and *Grammar of Science*, 1900; page 428.

the proper data, it is possible that the *positive* association may become a *significantly positive* one. Since excess of dark eyes in the Scottish population has been here shown to occur in densely populated parts, the dark-eyed class here at any rate belongs largely to the poorer section of the population. But the lower classes are more fertile than the upper classes. If the dark-eyed portion of the lower classes is more fertile than the remaining portion, and if a selective death rate does not operate against the dark-eyed, this would go far to explain the excess of dark eyes in densely populated parts not explainable by the presence of foreigners or of migrants from contiguous rural areas.

VIII. *Relationships between Pigmentation and Physical and Mental Defects.* In a recent memoir[*], already referred to, it was shown, using the division analysis results of the present data, that cases of insanity were in excess of the mean in areas where there was an excess of light eyes in the population. The enquiry has been extended in order to note whether excess of any particular hair colour or eye colour is associated with physical or mental defects such as blindness, deafness and imbecility. The following results were obtained, the results for insanity cases being included. The figures used in comparing the results were taken from the Census Report 1901.

TABLE XLII.

Relationships between Pigmentation and certain Defects or Affections.

Hair Colour.

Defect or Affection	Fair		Red		Medium		Dark		Jet Black	
	r	$\frac{r}{E_{(r=0)}}$	r	$\frac{r}{E_{(r=0)}}$	r	$\frac{r}{E_{(r=0)}}$	r	$\frac{r}{E_{(r=0)}}$	r	$\frac{r}{E_{(r=0)}}$
Insanity ...	−·024	−·10	−·582	−2·28	−·128	−·50	·340	1·33	·084	·33
Imbecility or Feeble-mindedness ...	·608	2·38	−·213	−·83	−·942	−3·69	·672	2·63	·893	3·50
Blindness ...	·565	2·22	·006	·02	−·868	−3·40	·546	2·14	·885	3·47
Deafness ...	·300	1·18	·054	·21	−·707	−2·77	·572	2·24	·789	3·10
Deaf and Dumb ...	·126	·49	·148	·58	−·136	−·53	−·026	−·10	·273	1·07

Eye Colour.

Defect or Affection	Blue		Light		Medium		Dark	
	r	$\frac{r}{E_{(r=0)}}$	r	$\frac{r}{E_{(r=0)}}$	r	$\frac{r}{E_{(r=0)}}$	r	$\frac{r}{E_{(r=0)}}$
Insanity ...	−·072	−·28	·695	2·73	−·322	−1·26	−·482	−1·89
Imbecility or Feeble-mindedness ...	·841	3·30	−·253	−·99	−·753	−2·96	−·547	−2·15
Blindness ...	·951	3·73	−·464	−1·82	−·775	−3·04	−·442	−1·73
Deafness ...	·819	3·21	−·386	−1·51	−·609	−2·39	−·489	−1·92
Deaf and Dumb ...	·309	1·21	−·453	−1·78	−·118	−·46	·149	·58

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[*] *Biometrika*, Vol. v. p. 342.

These results show that the distribution of cases of mental affection differs from those of the three other classes of defects. Excesses in the number of cases of imbecility, blindness and deafness occur in regions of excess of blue eyes and dark and jet black hair. From the results of the enquiry into the relationship between the Gaelic speaking portion of the population and pigmentation, it was shown that these were the classes correlated positively with excess of Gaelic speaking people. The correlation between this portion of the population and the four groups were accordingly calculated when it was found to confirm the conclusion that the Gaelic portion was correlated positively to those groups as expected, as the following table (Table XLIII.) shows:

TABLE XLIII.

Relationship between the Gaelic speaking Population and Defects.

Defect or Affection	Value of r	$\frac{r}{E_{(r=0)}}$
Deaf ...	·865	3·39
Blind ...	·884	3·47
Imbeciles ...	·788	3·09
Deaf and Dumb ...	·295	1·16

From whatever cause, therefore, a significantly greater number of cases of imbecility, blindness and deafness occur in Gaelic speaking regions than occur throughout the country in general. Emigration of the fitter portion of the inhabitants from the west in greater proportion than from other parts of Scotland would explain the occurrence of larger proportions of cases of defect in the Highlands. It must not be concluded therefore that Gaelic speaking Scots on an average are in any way inferior physically to Lowland Scots—perhaps the reverse is the case—or that a really higher proportion of defects exist among the race or races which speak the Gaelic language.

(10) *Degree of resemblance between the Boy and Girl Populations in each of the Colour Classes.*

It has been seen in a general way that the boy and girl populations agree in many localities in showing excess or defect frequencies in the various classes compared with the general population, and in several cases it was found that the populations differed, excesses in one sex being associated with defects in the other and *vice versa*. It is necessary therefore that the difference between the two populations generally should be measured. It will be seen then which of the classes shows the greatest agreement and which the greatest difference, or whether there is any appreciable difference in the extent of association or independence of the two sexes as separate populations.

(α) The degree of resemblance between the boy and girl populations in the same localities was determined, using in the first instance the percentage figures as found for the eight great divisions of Scotland. If x_m = deviation from the mean percentage of any class in any division for boys, x_f = the corresponding deviation from the percentage in the same division for girls, σ_m and σ_f the standard deviations of the respective percentage distributions,

$$r=\frac{\Sigma x_m x_f}{N\sigma_m\sigma_f}$$

and measures the general degree of resemblance between the boy and girl populations in the same division.

(β) In the second instance the values of the relative local differences found for counties and cities were used. If l_m = the relative local difference of any class for boys, and l_f = the corresponding relative local difference of the same class in the same locality for girls, then

$$r=\frac{\Sigma l_m l_f}{N\sigma_{l_m}\sigma_{l_f}}$$

and is a measure of the general resemblance between the boy and girl populations on the county and city basis of grouping.

(γ) In the third instance the counties alone were used, the cities being included in their respective counties while percentages were used as the basis, just as in the case of the great divisions. The following results were obtained:

TABLE XLIV.

Degree of Resemblance between the Boy and Girl Populations.

Colour	Values of r percentages Divisions	Values of r Counties and Cities—*RLD.*	Values of r Percentages Counties
Hair:			
Fair ...	·83	·83	·63
Red ...	·73	·68	·49
Medium ...	·93	·87	·74
Dark ...	·72	·68	·72
Black ...	·89	·71	·73
Average ...	·82	·75	·66
Eyes:			
Blue ...	·99	·95	·92
Light ...	·92	·86	·82
Medium ...	·85	·83	·79
Dark ...	·91	·91	·91
Average ...	·92	·89	·86

These results show that on an average any excess or defect in the boy population from the general mean in any locality is accompanied in about 70 to 90 per cent. of the cases by a corresponding excess or defect in the girl population and *vice versa*. The agreement is least in the case of red hair.

It may be of interest to point out that Tschepourkowsky has determined the mean resemblance between man and woman to be about ·8, the characters studied interracially being stature, relative arm length, cephalic index and four other measurable characters*.

(11) *The Colour Characteristics of the Population of Greater Glasgow and Environs.*

I. *Introductory.—Tables of classified data.* The city of Glasgow deserves special investigation for many reasons. (1) By far the largest in Scotland, the second city of the Empire contains one-fifth of the total population of the country. (2) Glasgow and the immediately adjacent counties, that is, Lanark, Renfrew, Ayr, Dumbarton and Stirling, contain one-half of the whole Scottish population. (3) Not only are these counties the most densely populated ones, but Glasgow itself greatly exceeds any Scottish town in the density of its population. (See Table LIII.) (4) The Census shows it to contain a much larger proportion of foreigners than any other town in Scotland. The Gaelic speaking population owing to its proximity to the Highlands is well represented. Ireland is also well represented. (5) Finally, it has been shown from the results of the present analysis that the great western city diverges in an extreme degree from the rest of Scotland not only in the distribution of hair colour of its school population but also in the distribution of eye colour, both for boys and girls.

The following table (Table XLV.) shows the observed and expected results for Glasgow and Govan and Glasgow proper, the expected results meaning of course those which would occur on an even distribution with respect to colour of the whole of the school children throughout Scotland.

TABLE XLV.

Glasgow and Govan.

Result	Hair					Eyes			
	Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark
Observed ...	17809	4179	36528	21809	965	9941	24661	27021	19667
Expected ...	21267	4308	34240	20478	997	11986	24644	26325	18335
The observed result compared with the expected one is ...	3458 less	129 less	2288 greater	1331 greater	32 less	2045 less	17 greater	696 greater	1332 greater

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* *Biometrika*, Vol. IV. pp. 161—168.

TABLE XLV.—(*continued*).

Glasgow Proper.

Result	Hair					Eyes			
	Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark
Observed ...	12734	2984	25967	16042	716	6736	17634	19802	14271
Expected ...	15290	3094	24606	14734	719	8628	17714	18934	13167
The observed result compared with the expected one is ...	2556 less	110 less	1361 greater	1308 greater	3 less	1892 less	80 less	868 greater	1104 greater

From the foregoing table it is seen that there are about 3500 less than the expected number of fair-haired children, about 2300 more medium haired and over 1300 more dark-haired. There are 2000 less blue-eyed children than expected, about 700 more medium eyed and over 1300 more dark-eyed children. Such differences, even with the large numbers dealt with in Glasgow, have a definite significance and are not differences which would occur in making a random draw of the same numbers from the general population.

In the county and district analyses, Glasgow has been treated as a unit. The city has been contrasted as a whole with the neighbouring counties and also with the immediately surrounding population, a population which has been divided up into districts. In both cases, it has been shown to be unlike those outside populations. It seems highly desirable therefore to examine Glasgow from the inside in order to see what is the cause of the great difference; whether, analysed intra-locally, the population of the city is different in different parts of the city; and whether these various divisions agree with or differ from the surrounding suburban areas.

Under the School Board of Glasgow the city is divided into ten educational districts. The accompanying table (Table XLVI.) gives a list of the districts and their respective schools:

In order to have approximately equal numbers in the various areas dealt with by the author, Calton, Camlachie and Bridgeton were grouped into one pigmentation district; Tradeston, Gorbals and Hutchesontown, three other educational districts, were grouped into another pigmentation district. The following pigmentation districts were also constituted for the environs of Glasgow: North Suburban, South Suburban, East Suburban and West Suburban. The following table (Table XLVII.) shows how the pigmentation groups of Greater Glasgow were made up, while the succeeding table (Table XLVIII.) shows the actual frequencies of the various classes for these districts. The results of the analysis of these figures

TABLE XLVI.

Educational District. Name of School.

I. Anderston District.

1. Bishop Street.
2. Finnieston.
3. Overnewton.
4. Anderston.
5. Kelvinhaugh.
6. Kent Road.
*7. Glasgow High School.
8. Washington Street.

II. Milton District.

1. Dobbie's Loan.
2. Henderson Street.
3. Rockvilla.
4. Milton.
5. Garnetbank.
*6. Glasgow High School for Girls.
7. Kay.
8. Oakbank.
9. Grove Street.
10. Woodside.
11. St George's Road.
12. Springbank.
13. Napiershall.
*14. Pupil Teachers' Institute.
15. Dunard Street.
16. Willowbank.
*17. Woodlands Institute School (for Cripple Children).

III. St Rollox District.

1. Kennedy Street.
2. Springburn.
3. Keppochhill.
4. Freeland.
5. Martyrs'.
6. St David's.
7. Townhead.
8. Elmvale.
9. Provanside.
*10. Hydepark.

IV. Dennistoun District.

1. Wellpark.
2. St Rollox.
3. Dovehill.
4. Dennistoun.
*5. Whitehill.
6. Alexander's.
7. Petershill.
8. Rosemount.
9. Alexandra Parade.
*10. Golfhill.
*11. Haghill.

V. Calton District.

*1. Tureen Street.
2. St James's.
3. Calton.

VI. Camlachie District.

1. Thomson Street.
2. Barrowfield.
*3. Parkhead.
4. Camlachie.
5. Campbellfield.
6. Annfield.
*7. Newlands.
*8. Quarrybrae.

VII. Bridgeton District.

1. Rumford Street.
2. Hozier Street.
*3. John Street.
4. Springfield.
5. Dalmarnock.
6. Queen Mary Street.
*7. Strathclyde.
8. Special School for Cripple Children.

VIII. Tradeston District.

*1. Centre Street.
2. Crookston Street.
3. Shields Road.
4. Sir John N. Cuthbertson.
*5. Scotland Street.

IX. Gorbals District.

1. Greenside Street.
2. Abbotsford.
3. Gorbals.

X. Hutchesontown District.

1. Rose Street.
2. Camden Street.
3. Oatlands.
*4. Mathieson Street.
5. Wolseley Street.
6. Adelphi Terrace.
*7. Hayfield.

* No returns were received from these schools.

are given in Tables XLIX. and L. (Table XLIX. Relative Local Differences and Table L. General Divergency). The results are also shown diagrammatically in Maps LV. to LXXVIII.

TABLE XLVII.

	Name of Pigmentation Groups	Pigmentation Group embraces
I	Anderston	The Wards of Anderston, Broomielaw, Sandyford, Exchange, Blythswood, part of Park
II.	Milton	The Wards of Cowcaddens, Park (part of), Woodside (part of)
III.	St Rollox	The Wards of Townhead, Cowlairs (part of), Springburn (part of)
IV.	Dennistoun	Dennistoun Ward
V.	Calton, Camlachie and Bridgeton ...	The Wards of Calton, Whitevale, Milend, and Dalmarnock
VI.	Tradeston, Gorbals & Hutchesontown	The Wards of Kingston, Gorbals and Hutchesontown
VII.	South Govan	All the Govan School Board area south of the river
VIII.	Partick	Partick; Kelvinside Ward
IX.	South Suburban District	The Parishes of Eastwood, Cathcart, Rutherglen and Cambuslang
X.	North Suburban District	The Parishes of Cadder, New Kilpatrick, Old Kilpatrick and Baldernock
XI.	East Suburban District	The Parishes of Bothwell, Barony and Old Monkland
XII.	West Suburban District	The Parishes of Renfrew and Abbey (Paisley Burgh and Paisley landward)

II. *Analysis of Glasgow Data.* (*a*) *General Divergency in Colour.* (1) *Degree of General Resemblance of the various divisions of Glasgow to the General Population in Hair Colour.* It will be remembered that in the district analysis, the 13th district, Glasgow and Govan, exhibited the excessive divergencies from the general population as represented by $\log P = \overline{44}\cdot 8$ for boys and $\log P = 146\cdot 6$ for girls. In the county analysis the chief cities were treated separately from the counties and Govan was separated from Glasgow, when it was found that the values of $\log P$ fell—that is, less divergency was exhibited for Glasgow and Govan separately than for Glasgow and Govan together. Still the significance of the divergency was very great. Log P (boys) for Glasgow proper was $\overline{29}\cdot 5$ and for Govan $\overline{16}\cdot 9$. For girls the values were $\overline{120}\cdot 0$ and $\overline{34}\cdot 5$. Glasgow proper is thus much more divergent than Govan.

From the analysis of Greater Glasgow and environs, one is able to locate the areas of greatest divergency. Of all the pigmentation groups, the sixth group (Tradeston, Gorbals and Hutchesontown) stands out the most divergent in hair colour for both boys and girls. South Govan and Anderston follow a long way behind. From the fact that there is a large excess of medium and dark hair in the girl population, Calton, Camlachie and Bridgeton as a group is as greatly divergent as South Govan, but the boy population is quite a good sample of the

TABLE XLVIII.

Frequencies of the Colour Classes in the various Divisions of Glasgow.

BOYS.

	Hair					Eyes				Totals
	Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark	
Anderston	717	199	1654	960	34	414	1197	1073	880	3564
Milton	1161	322	2411	1322	51	626	1634	1739	1268	5267
St Rollox	741	160	1378	710	15	313	955	1028	708	3004
Dennistoun	825	196	1552	870	34	402	1082	1166	827	3477
Bridgeton Group	1320	286	2518	1448	61	605	1597	2088	1343	5633
Tradeston Group	1122	282	2842	1749	107	527	1829	2136	1610	6102
Partick	932	224	1947	986	49	723	1234	1251	930	4138
Govan South	1054	266	2408	1304	67	628	1554	1669	1248	5099
South Suburban Area ...	970	247	1936	1170	34	634	1283	1425	1015	4357
East Suburban Area ...	1373	293	2681	1493	68	732	1745	2178	1253	5908
North Suburban Area ...	981	267	2082	1121	39	505	1406	1566	1013	4490
West Suburban Area (Paisley)	864	182	1477	787	75	496	983	1123	783	3385
Totals	12060	2924	24886	13920	634	6605	16499	18442	12878	54424

GIRLS.

	Hair					Eyes				Totals
	Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark	
Anderston	681	172	1479	1005	43	470	979	1092	839	3380
Milton	1149	283	2168	1482	58	654	1633	1599	1254	5140
St Rollox	836	163	1601	1007	46	421	1103	1235	894	3653
Dennistoun	729	143	1422	834	43	384	924	1141	722	3171
Bridgeton Group	1242	289	2586	1643	50	630	1679	2117	1384	5810
Tradeston Group	1190	272	2807	1873	88	640	1865	2134	1591	6230
Partick	870	205	1721	1025	48	708	1159	1107	895	3869
Govan South	1051	249	2344	1321	51	545	1593	1640	1238	5016
South Suburban Area ...	1000	189	1821	1106	32	528	1309	1362	949	4148
East Suburban Area	1448	306	2294	1369	52	673	1577	1963	1256	5469
North Suburban Area ...	1080	220	1825	1095	29	532	1389	1364	964	4249
West Suburban Area (Paisley)	811	173	1389	857	76	497	949	1031	829	3306
Totals	12087	2664	23457	14617	616	6682	16159	17785	12815	53441

TABLE XLIX.

Relative Local Differences. Greater Glasgow and Environs.

BOYS.

	Hair					Eyes			
	Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark
Anderston	− 6·71	·25	3·80	2·65	−1·60	− 5·17	4·29	−3·35	3·44
Milton	− 4·93	2·01	3·69	·12	−1·86	− 5·75	1·14	·46	3·11
St Rollox	− ·36	− ·40	2·88	−1·78	−3·73	− 6·61	1·78	1·76	1·67
Dennistoun	− 1·68	·38	1·63	− ·01	−1·45	− 5·20	1·05	1·03	2·10
Bridgeton Group ...	− 2·66	−1·38	2·18	1·18	−1·14	− 8·41	−3·24	7·03	2·79
Tradeston Group ...	−11·99	−3·01	5·26	6·63	3·58	−13·46	− ·58	3·85	7·74
Partick	− 3·64	− ·22	4·94	−1·80	− ·39	5·16	− ·69	−3·44	·26
South Govan ...	− 7·13	− ·87	5·74	·91	·42	− 4·78	·26	·02	3·75
South Suburban Area	− 4·13	·52	1·55	2·80	−2·81	− ·21	−1·25	− ·02	1·58
East Suburban Area	− 3·07	−1·81	3·30	·43	− ·69	− 4·99	1·31	6·87	−2·06
North Suburban Area	− 4·84	1·36	4·22	− ·10	−2·32	− 6·52	1·48	3·11	·41
West Suburban Area	·78	− ·29	·42	−2·41	−5·09	− ·01	−1·62	·57	1·16

GIRLS.

	Hair					Eyes			
	Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark
Anderston	− 9·55	− ·00	3·44	5·83	·33	− 1·59	−1·71	·31	2·88
Milton	− 8·24	1·37	1·93	5·72	− ·54	− 4·37	2·30	−1·48	2·83
St Rollox	− 6·20	−1·74	3·66	3·03	·27	− 5·73	− ·15	2·28	2·49
Dennistoun	− 5·64	−1·50	4·58	1·17	·76	− 4·40	−1·44	4·76	·01
Bridgeton Group ...	−10·47	− ·41	5·71	5·11	−2·47	− 8·73	−2·38	7·23	1·95
Tradeston Group ...	−14·93	−2·63	6·81	8·57	1·48	−10·33	− ·65	3·76	5·30
Partick	− 6·95	·60	4·61	1·57	·18	6·04	− ·48	−4·63	·56
South Govan ...	−10·39	− ·41	8·53	1·54	−1·26	− 8·05	2·26	·97	3·28
South Suburban Area	− 4·84	−1·58	4·01	1·89	−2·61	− 3·91	1·76	1·08	·18
East Suburban Area	− 1·60	1·72	1·64	− ·63	−1·77	− 5·39	−2·40	6·14	·37
North Suburban Area	− 2·97	·26	2·78	·56	−3·17	− 4·34	3·41	·06	− ·11
West Suburban Area	− 3·76	·38	1·35	·70	5·77	·27	−2·02	−1·08	3·20

TABLE L.

Divergency in Hair Colour and Eye Colour. Greater Glasgow and Environs.

	Hair				Eyes			
	Boys		Girls		Boys		Girls	
	Log *P*	*Q*	Log *P*	*Q*	Log *P*	*Q*	Log *P*	*Q*
Anderston	$\overline{10}\cdot7$	·0139	$\overline{20}\cdot6$	·0201	$\overline{11}\cdot5$	·0143	$\overline{2}\cdot2$	·0066
Milton	$\overline{6}\cdot2$	·0114	$\overline{15}\cdot0$	·0179	$\overline{8}\cdot9$	·0119	$\overline{6}\cdot8$	·0106
St Rollox	$\overline{4}\cdot5$	·0090	$\overline{9}\cdot6$	·0137	$\overline{9}\cdot3$	·0130	$\overline{8}\cdot9$	·0122
Dennistoun	$\overline{1}\cdot3$	·0150	$\overline{8}\cdot9$	·0127	$\overline{6}\cdot7$	·0104	$\overline{7}\cdot5$	·0117
Bridgeton	$\overline{2}\cdot3$	·0069	$\overline{25}\cdot4$	·0226	$\overline{22}\cdot2$	·0204	$\overline{22}\cdot2$	·0210
Tradeston	$\overline{36}\cdot3$	·0263	$\overline{52}\cdot6$	·0321	$\overline{44}\cdot2$	·0286	$\overline{25}\cdot0$	·0224
Partick	$\overline{5}\cdot5$	·0101	$\overline{10}\cdot8$	·0143	$\overline{6}\cdot0$	·0110	$\overline{10}\cdot9$	·0137
Govan	$\overline{11}\cdot0$	·0150	$\overline{25}\cdot2$	·0226	$\overline{6}\cdot2$	·0109	$\overline{14}\cdot4$	·0166
South Suburban Area ...	$\overline{5}\cdot2$	·0105	$\overline{7}\cdot1$	·0125	$\overline{1}\cdot6$	·0034	$\overline{3}\cdot1$	·0081
East Suburban Area ...	$\overline{3}\cdot4$	·0081	$\overline{2}\cdot7$	·0063	$\overline{12}\cdot6$	·0149	$\overline{11}\cdot2$	·0149
North Suburban Area ...	$\overline{7}\cdot8$	·0116	$\overline{4}\cdot5$	·0093	$\overline{9}\cdot2$	·0131	$\overline{5}\cdot5$	·0099
West Suburban Area ...	$\overline{6}\cdot7$	·0109	$\overline{9}\cdot8$	·0135	$\overline{1}\cdot6$	·0035	$\overline{4}\cdot0$	·0069

general population—there is no great excess or defect in any of the classes. Milton, the north suburbs and west suburbs are about equally divergent for boys, and show a fall as compared with those just mentioned. Then follow Partick, St Rollox and the south suburbs. These show a distinct approach to uniformity of distribution and resemble the general population. Finally the boy populations of the adjacent areas of Calton, Camlachie, Bridgeton, Dennistoun and the east suburbs are fair samples of the general population. Of all the pigmentation groups, only the population of the east suburbs among the girls show resemblance to the general population. As indicated by the boy results, the east end of Glasgow is thus the least divergent and the adjacent southern area—Tradeston, etc.—the most divergent.

(2) *Eye Colour.* On examining the results for eye colour, it is seen that Tradeston, Gorbals and Hutchesontown again come out most divergent. Clearly there are elements in this population of a different character from the population in general. Calton, Camlachie and Bridgeton are also very divergent. South Govan follows in the decreasing scale, then Anderston and the other groups. The south and west suburban areas are quite like the general population, but the east suburban group, partaking of the character of the east end of the city, is as divergent as Anderston, a populous centre.

Thus the special features of the divergency analysis of the component parts of Greater Glasgow are that (1) the eastern portion of the city is quite like the general population in hair colour but is most unlike in eye colour; (2) the suburban areas are much liker the general population than the purely city areas;

(3) in several cases the divergencies for the boy and girl populations are unequal. When this is the case, the girl population has the greater divergency.

(β) *Individual Classes.* (1) *Hair Colour.* The relative local differences have in all cases been calculated and show definitely the cause of the divergencies in each pigmentation group. It will be recalled that fair hair is in defect in the city generally. The difference between the city and the general population is very great, 12 and 24 times the standard deviation of sampling of the differences for boys and girls respectively. There is a distinct fall in the magnitude of the difference in taking Glasgow to pieces. Still in no case is fair hair in excess in the city. There is only a slight excess in the west suburban group. Tradeston is prominent in the magnitude of its negative difference, and resembles the figure for Glasgow generally. South Govan and Anderston, also in the heart of the city, follow with large differences. Milton and the three suburbs, north, south, and east, differ in a moderate degree, while St Rollox, Dennistoun and Bridgeton for boys are passable as samples of the general population, such negative differences as they show being quite possible in a draw from an evenly distributed population. In the girl population, however, only the four suburbs are passable as representative of the general population. All the city groups differ widely from the general average. In a word, one or two of the northern areas in Glasgow possess the average proportion of fair hair and are thus somewhat like the suburbs, but the densely populated areas in the city generally are awanting in the proper proportion of the fair-haired class.

There are slight excesses of red hair in Milton, Partick and the north, east, and south suburban groups, but in none of the cases are the excesses significant. Thus the uniformity of the distribution of this colour class is shown to exist practically all over the country, the north-east of Scotland being the exception. No grouping occurs to speak of in the densely populated city of Glasgow and no defect in the frequency of this class occurs to an extent in the least significant. Town and country are thus much alike with regard to this class.

Medium or brown hair however occurs in quite excessive frequencies in several of the city groups, but is less frequent in the suburbs generally. In the west suburban area, Paisley and Renfrew, the proportion is quite an average one. Tradeston, Gorbals and Hutchesontown (♂ and ♀); Calton, Camlachie and Bridgeton (♀); and South Govan (♂ and ♀) are the areas of greatest excess of the various shades of brown constituting the medium class. Dennistoun (♂) and Milton (♀) are fair samples of the general population in this class. In the dark-haired class, Tradeston, Gorbals and Hutchesontown again stand out. The greatest excess of this class is found over the area of these three divisions. Anderston and the south suburban group for boys show perhaps significant excess, but the differences in the other groups although positive are not significant. In the suburbs generally there are less dark-haired children proportionally than in the heart of the city, and the northern portion of the city itself has a less proportion than the southern and eastern portion. With regard to the small class of jet black haired persons, Tradeston, Gorbals and Hutchesontown are the only divisions of the city which show significant excess. Excess occurs outside the city only in one suburban group, that of the west, Paisley and Renfrew.

(2) *Eye Colour.* The blue-eyed class, much below the average for Glasgow as a whole, shows significant negative differences in all the divisions and groups excepting the Partick and Kelvinside group, which shows a decided excess. Light eyes are in excess only in Anderston, the heart of the city, and in the north suburban area. There is a slight excess among girls in the South Govan group. Medium eyes are in excess in the east of Glasgow and in defect in the west. Starting in the north suburban area, the excess appears in St Rollox, Dennistoun and the Bridgeton group and finally in the Tradeston group. Govan, the south and west suburbs are like the general population. The defect is greater in Partick. The distribution of dark eyes is interesting on account of the fact that excess in Scotland generally is limited, when a large number of cases is considered, to one region of Scotland, that of Perthshire and Forfarshire. The only suburban area showing excess of this class is the west (Paisley and Renfrew) for girls. There is a slight excess in the boy population of the south suburban area. In the city, Partick is different from the rest of the population in that it possesses the average number—it is quite like the general population for this class. All the other divisions and groups show excess of dark eyes. It is most marked in the Tradeston group, the excess there being highly significant. South Govan follows and then Anderston and Milton. The excess is significant for boys in the Bridgeton group, but not quite significant among the girls of that group.

(γ) *General view.* The predominant colours of each of the divisions of Glasgow can now be stated. They are given in the following two tables. Table LI. shows significant positive differences only and these are classed so as to show the intensity of the excesses. Table LII. is a condensation of Table LI. and gives a brief specification of each division.

Taking a general survey of the pigmentation distribution of Greater Glasgow as shown by an analysis of its divisions and the environs, one sees that the excesses of medium and dark hair and medium and dark eyes (found in considering Glasgow as a unit) are not evenly distributed over the city and suburbs. *It is however the predominant feature of the more densely populated and larger portion of the city to be brown or dark in hair colour and medium or dark in eye colour. This of course but confirms the general result in comparing density with pigmentation.* There are some interesting features in the colour distribution which deserve special mention. The occurrence in certain parts of Glasgow of excesses of classes generally deficient in the city (either with or without the prevailing colours) is striking. Why, for instance, should Anderston have an excess of light eyes in the boy population? Why should Milton be the only district having even a slight excess of red hair? Why should the Tradeston group be the only one in the city having an excess of the jet black class, and be otherwise so very divergent as it has proved to be? Why should Partick be the only division in Glasgow having blue eyes in excess,

TABLE LI.

Specification of the Greater Glasgow Population.

(Only significant positive relative local differences shown.)

BOYS.

	Anderston	Milton	St Rollox	Dennistoun	Bridgeton Group	Tradeston Group	Partick	South Govan	S. S.	E. S.	N. S.	W.S.
Fair ...	—	—	—	—	—	—	—	—	—	—	—	—
Red ...	—	2	—	—	—	—	—	—	—	—	—	—
Medium ...	4	4	3	—	—	5	5	6	—	—	4	—
Dark ...	3	—	—	—	—	6	—	—	3	—	—	—
Jet Black ...	—	—	—	—	—	4	—	—	—	—	—	5
General Divergency for hair colour	3	1	1	0	0	7	1	3	1	0	2	1
Blue ...	—	—	—	—	—	—	5	—	—	—	—	—
Light ...	4	—	—	—	—	—	—	—	—	—	—	—
Medium ...	—	—	—	—	7	4	—	—	—	7	3	—
Dark ...	3	3	—	—	3	7	—	4	—	—	—	—
General Divergency for eye colour	3	2	2	1	7	7	1	1	0	3	2	0

GIRLS.

	Anderston	Milton	St Rollox	Dennistoun	Bridgeton Group	Tradeston Group	Partick	South Govan	S. S.	E. S.	N. S.	W.S.
Fair ...	—	—	—	—	—	—	—	—	—	—	—	—
Red ...	—	—	—	—	—	—	—	—	—	2	—	—
Medium ...	3	—	4	4	6	7	5	9	4	—	3	—
Dark ...	6	6	3	—	5	9	—	—	—	—	—	—
Jet Black ...	—	—	—	—	—	—	—	—	—	—	—	6
General Divergency for hair colour	6	4	2	2	7	7	3	7	2	0	1	2
Blue ...	—	—	—	—	—	—	6	—	—	—	—	—
Light ...	—	—	—	—	—	—	—	—	—	—	3	—
Medium ...	—	—	—	5	7	4	—	—	—	6	—	—
Dark ...	3	3	—	—	—	5	—	3	—	—	—	—
General Divergency for eye colour	0	1	2	2	7	7	3	4	0	3	1	1

Differences between 2·5 and 3·5 are here class 3; between 3·5 and 4·5 class 4; between 4·5 and 5·5 class 5 and so on. The object is to show the degrees of difference even in significant cases. In the general analysis of the whole country, all differences above 3·5 are shown as one class. In the maps however all differences above 3·5 are included in class 4, to be in conformity with the general scheme.

TABLE LII.

	Boys		Girls	
	Hair	Eyes	Hair	Eyes
Anderston ...	Medium, Dark	Light, Dark	Medium, Dark	Dark
Milton ...	Slightly red, Medium	Dark	Medium	Dark
St Rollox ...	Medium	—	Medium, Dark	—
Dennistoun ...	—	—	Medium	Medium
Bridgeton Group	—	Medium	Medium, Dark	Medium
Tradeston Group	Medium, Dark, Black	Medium, Dark	Medium, Dark	Medium, Dark
Partick ...	Medium	Blue	Medium	Blue
South Govan ...	Medium	Dark	Medium	Dark
South Area ...	Dark	—	Dark	—
East Area ...	—	Medium	Red	Medium
North Area ...	Medium	Medium	Medium	Light
West Area ...	Jet Black	—	Jet Black	—

the only excess in hair colour (scarcely significant) being that of the dark class? Finally there is the general problem of the colour characters of Glasgow. Why should this population differ so markedly in pigmentation from the general population of Scotland? This problem will now be solved as far as it can be solved from the data of the survey and other available information.

III. *Specific Elements in the Glasgow Population, causing Divergency.* (*a*) *Introductory.* In one of the previous sections (Section 9) it was proved (1) that excess of blue eyes, dark hair, and jet black hair, are associated with regions of excess of the Gaelic speaking population; and (2) that excess of medium or brown hair, medium eyes and dark eyes are associated with more densely populated regions, which in turn are also regions of excess of foreigners. This means, briefly, that blue eyes, dark, and jet black hair are probably typical of Gaelic speaking people* although of course all the other classes are represented in this population, and that brown hair is typical of densely populated areas which in turn have a proportion above the average of foreign immigrants.

(*β*) *The Gaelic Speaking Population.* Taking the Gaelic speaking population first, there is undoubtedly a large Scoto-Keltic or Highland element in Glasgow. At the last Census, no fewer than 18,279 persons could speak Gaelic and English in the city proper. This is equal to 9 per cent. of the total Gaelic speaking population. Taking Glasgow, Govan, Kinning Park and Partick, that is Greater Glasgow (without the environs), the Census shows that nearly 24,000 or 11·7 per cent., or more than one-ninth of the whole Gaelic population, is concentrated in the great western city. An analysis of the Census returns further shows Kelvinside, with 6·4 per cent.; Tradeston (Kingston Ward), with 5 per cent.; Milton (Park Ward), with 4·9 per cent.; Anderston, particularly Sandyford Ward, with 4·8 per cent., to be quite in excess of the general average for Greater Glasgow, which is 2·6 per cent. of the whole population of the city. Govan is also in excess, having 4·4 per cent. of Gaelic speaking people in its population. One seems justified in inferring that such a population distributed over Glasgow would have a marked effect on the nature of the distribution of colour. Since Glasgow is significantly darker than the general population, since dark hair is significantly associated with the Gaelic speaking population, and since at least one-ninth of the whole Gaelic speaking population resides in Greater Glasgow, the conclusion is inevitable that the Gaelic speaking portion contributes largely to the significance of the excess of dark hair. It is not contended that this is the whole cause of the significant excess, but it is a prominent factor. But it may be argued that blue eyes are in defect in Glasgow generally and since blue eyes are also associated with Gaelic speaking people, their presence does not seem, on this hypothesis, to affect the character of the distribution. The answer is: it must be borne in mind that the combination of blue eyes and fair hair in one person, that is the blonde type, is in great defect in Glasgow, thus diminishing the proportion of blue eyes to a great degree. There are also large excesses of dark eyes to which it will presently be seen the foreign element contributes. These and other factors prevail over the Gaelic factor and the theoretical excess of blue eyes is converted into an actual deficiency in this class, with one exception only. This exception is the Kelvinside and Partick group. Here a highly significant excess of blue eyes appears with an excess of dark hair, thus revealing the presence of the Gaelic speaking portion as one of the predominant causes of the divergency in these districts, for it has already been observed that in Kelvinside alone 6·4 per cent. (the highest percentage in any district in Glasgow) of the population speak Gaelic. Presence of excess of light eyes among boys in Anderston deserves notice. While it has been observed that excess of blue eyes is associated with the Gaelic speaking portion generally, it must be noted that Argyll has in its rural population 62 per cent. of Gaelic speaking people and has a large excess of light eyes. Excess of this class is therefore a characteristic of a section of the Highlands as it has been shown also to be of Ayr and Galloway which are closely allied in blood to the Highlands as it formerly was in language. It is highly probable that county immigrants and their descendants from Argyll, Ayr and Galloway, are at the present time in excess of the general proportion in Anderston generally, thus disturbing the balance in favour of an excess of light eyes in the boy population. In addition to this, there is the Irish element. Beddoe's results, already quoted, show an excess of light eyes in the Irish compared with the Scottish figures of the present data. The Gaelic element does not however account for excesses of medium hair and dark eyes in Anderston, although it would account for the excess of dark hair and light eyes. The general analysis shows Perthshire and Forfarshire to have significant excess of dark eyes, which has been suggested to account for the similar excess in Dundee and perhaps to some extent to explain the excess of the same class in Edinburgh. Are county immigrants and their descendants from these regions in excess also in Anderston and in Glasgow generally, for the excess of dark eyes is common practically over the whole of Glasgow although it is more highly significant in Tradeston, Govan, Anderston, Milton, and Bridgeton? I think this is unlikely. There must be some other factor or factors besides mere immigration from the Scottish Midlands. What are they?

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* Gaelic speaking people are not associated with dense areas as a whole. The correlation is negative, $r = -\cdot 39 \pm \cdot 2$. The association with sparsely populated parts is therefore not very high.

(γ) *The Foreign Population of Glasgow.* It was shown in the last section that the correlation between foreigners and density of population was very high. It was so high that on comparing foreigners and density of population separately with pigmentation, the same conclusion was reached for each. It could not however be said whether foreign immigrants were causing the excesses in the three classes named by their great numbers or whether the excesses were there independently of them, for, since foreigners came mainly to towns, it might be only through density as the common link that the correlation existed at all. The association between foreigners and density is however real. Foreign immigrants are likely to be found to reside in greater numbers in the most densely populated areas and in the smallest houses. Now it is very suggestive that, at the last Census, 9644 foreigners or 42·6 per cent. of the total number of foreigners in Scotland (22,627 in 1901) resided in Glasgow alone. It is also suggestive that of the great cities Glasgow is by far the most densely populated. The following table gives the relative densities of the chief towns in Scotland:

TABLE LIII.

Number of Persons per Square Mile in the Chief Towns of Scotland.

Town	Persons per Square Mile	Town	Persons per Square Mile
Pollockshaws ...	43,177	Coatbridge ...	12,830
Greater Glasgow ...	39,331	Musselburgh ...	12,826
Leith ...	33,787	Alloa ...	12,661
Rutherglen ...	30,537	Kirkcaldy ...	12,515
Dundee ...	28,069	Barrhead ...	11,916
Johnstone ...	27,859	Dumbarton ...	11,387
Port Glasgow ...	24,289	Falkirk ...	11,223
Motherwell ...	21,978	Perth ...	11,031
Edinburgh ...	20,089	Peterhead ...	10,991
Greenock ...	18,598	Inverness ...	10,514
Fraserburgh ...	17,510	Galashiels ...	10,085
Kilmarnock ...	17,125	Ayr ...	9,177
Hamilton ...	15,750	Brechin ...	9,086
Aberdeen ...	15,716	Stirling ...	8,552
Clydebank ...	14,959	Dunfermline ...	8,016
Dumfries ...	14,726	Kirkintilloch ...	7,992
Wishaw ...	14,535	Forfar ...	7,444
Bo'ness ...	13,889	Montrose ...	5,422
Airdrie ...	13,598	Renfrew ...	3,742
Hawick ...	13,434	Irvine ...	3,429
Arbroath ...	13,075	Rothesay ...	2,461

TABLE LIV.

Population in 1901 *of the Chief Towns in Scotland arranged in the order of their magnitude.*

Town	Population	Town	Population
Greater Glasgow ...	906,391	Stirling ...	18,403
Edinburgh ...	316,837	Hawick ...	17,303
Dundee ...	161,173	Port Glasgow ...	16,857
Aberdeen ...	144,117	Rutherglen ...	16,185
Leith ...	77,439	Galashiels ...	13,615
Greenock ...	68,142	Dumfries ...	13,092
Coatbridge ...	36,991	Montrose ...	12,427
Kilmarnock ...	34,165	Peterhead ...	11,794
Kirkcaldy ...	34,079	Musselburgh ...	11,711
Perth ...	32,873	Alloa ...	11,421
Hamilton ...	32,775	Forfar ...	11,397
Motherwell ...	30,418	Pollockshaws ...	11,183
Falkirk ...	29,280	Johnstone ...	10,503
Ayr ...	28,697	Kirkintilloch ...	10,502
Dunfermline ...	25,250	Barrhead ...	9,855
Arbroath ...	22,398	Irvine ...	9,618
Airdrie ...	22,288	Rothesay ...	9,378
Inverness ...	21,238	Bo'ness ...	9,306
Wishaw ...	20,873	Renfrew ...	9,296
Dumbarton ...	19,985	Fraserburgh ...	9,105
Clydebank ...	18,670	Brechin ...	8,941

From the results found in ascertaining the degree of association between density and pigmentation, excesses of medium hair, medium eyes and dark eyes would be expected in Glasgow. But the most densely populated parts of the city have been proved to be likely to contain more foreigners than the less densely populated parts. Thus the greater the number of persons per square mile a population has, the greater will be the expected excess of the three classes associated with excess of foreign immigrants. Now the only large group which has the complete density-colour specification (and in the greatest excess) and which has the highest general divergency, is the group of divisions Tradeston, Gorbals and Hutchesontown. It is highly probable that the foreign element may be one of the factors in the divergency of this group—foreign immigrants may contribute to the excesses in one or more of the classes there. In order that an estimate of the probable number of school children of foreign parentage attending Glasgow schools might be formed, an enumeration of those possessing foreign surnames was made. At the same time the colour characters were noted and classified. Only those surnames which were unmistakably foreign were taken, so that the estimate is most probably below instead of above the actual figures. The following is the result of the enumeration for the various pigmentation groups of Greater Glasgow. The environs were not included.

TABLE LV.

Division or Group	Children in each division having foreign surnames, per cent. of the total number of children in Greater Glasgow having foreign surnames
Anderston	12·51
Milton	7·78
St Rollox	1·28
Dennistoun	7·98
Calton, Camlachie and Bridgeton	3·85
Tradeston, Gorbals and Hutchesontown ...	59·21
South Govan	6·50
Partick and Kelvinside	·89
Totals	100·00

This result is striking and confirms what has been said as to the Tradeston group. In two schools alone, Gorbals and Adelphi Terrace, about 500 children had distinctly foreign, mostly Jewish, surnames. The colour characters of these children were tabulated with the following result (Table LVI.):

TABLE LVI.

Children with Foreign Surnames

Colour	Gorbals per cent.	Adelphi Terrace per cent.
Hair:		
Fair ...	3·14	8·00
Red ...	1·04	2·29
Medium ...	37·98	26·29
Dark ...	53·31	56·57
Jet Black ...	4·53	6·86
Eyes:		
Blue ...	3·14	1·71
Light ...	17·42	17·71
Medium ...	21·25	18·86
Dark ...	58·19	61·71

In Gorbals Public School 41 per cent. and in Adelphi Terrace Public School 44 per cent. of the children of foreign parents had dark hair associated with dark eyes in the same individual. Thus the Jewish element alone in the Tradeston group is sufficient to account for the excesses in dark hair, jet black hair, and dark eyes, found in this populous district.

It has been directly ascertained that the foreign element in the Tradeston group is largely made up of Jews of Russian and Polish origin. From the Census Report it is seen that of the whole number of foreigners in Glasgow, 60 per cent.

are Russians and Poles; 15 per cent. are Italians; 10 per cent. belong to other races whose predominant hair colour is known to be brown or dark. Only 15 per cent. belong to Northern races or peoples likely to have a moderate or large proportion of the blonde type, namely, Germans, Swedes, Norwegians, Dutch and Belgians. Thus wherever foreigners congregate together in the city anywhere they are likely to increase the darkness of the population rather than otherwise. The general effect outside the Tradeston group may be small, since the foreign population is more scattered, and is in much smaller proportion consequently in every division but Tradeston and Gorbals. Any effect Italians have would be in the direction of excess of medium hair and dark eyes since Livi* has shown these are the typical classes among Italians, but there is no evidence of the concentration of members of this race as a group in the city†.

(δ) *The Irish Population of Glasgow.* The Gaelic speaking population has been shown to be likely to influence the colour distribution of Glasgow in the direction of excess in the dark and jet black haired classes and also probably in the blue-eyed and light-eyed classes. The divisions likely to be influenced have also been pointed out. But there is another very important element in the Glasgow population still to be considered. It is estimated by reliable authorities that there are about 100,000 Irishmen in Glasgow. Over 40,000 as a minimum are Protestants‡. The proportion of persons of Irish origin in other parts of Scotland is very small. The effect of this large population, if its colour characters differed from those of the Scottish population, would be very great. In one of the previous sections (Section 9, Table XXXVIII.) it was pointed out from Beddoe's figures that compared with Scotland, Ireland was likely to have much higher proportions of light eyes (light and blue, however; Beddoe grouped both together as one class), dark hair and jet black hair. Beddoe's figures of course refer to the adult Irish population. It therefore seemed desirable to get an estimate of the distribution of colour among Irish children. The colour characters of school children, stated by the teachers to be of Irish origin, in certain Glasgow schools were tabulated, when the figures given in the accompanying table (Table LVII.) were obtained.

These figures confirm the conclusion from Beddoe's results. Dark and jet black hair are both in excess compared with the Scottish population. The distribution therefore differs markedly from the general Scottish distribution. If children of Irish origin were present in a moderately large proportion in any of the districts, they would sensibly affect the colour distributions in the schools of Glasgow. In order to gain some information as to the number of children of Irish origin in each of the pigmentation districts of Glasgow, the author recently communicated with the headmasters who very kindly sent in a return showing the numbers approximately of children of non-Scottish origin, in three classes: (a) foreign, (β) Irish,

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* R. Livi, *Antropometria Militare*, Roma, 1898.

† Canon Ritchie has very kindly supplied me with figures from the Roman Catholic Clergymen of Glasgow which show that Italians are nearly in even proportions in the various divisions.

‡ This estimate is based on figures supplied by Orangemen, through the kindness of Mr Hugh Berrie, Glasgow.

TABLE LVII.

Colour Distribution of Children of Irish origin.

	Per Cent.		Irish Adults
	Boys	Girls	Beddoe
Hair:			
Fair ...	24·31	22·11	10·4
Red ...	4·53	5·09	4·6
Medium ...	40·32	35·13	33·4
Dark ...	27·26	33·07	40·5
Jet Black ...	3·58	4·60	11·0
Eyes:			
Blue ...	22·53	21·23	66·5
Light ...	26·52	26·03	
Medium ...	28·84	28·38	14·7
Dark ...	22·11	24·36	18·6

(γ) English and Welsh. The following table (Table LVIII.) shows the percentages of each of the three classes based on the returns received. The author desires cordially to thank the teachers of Glasgow for supplying the additional information asked for—information which assists in the verification of some of the conclusions as to the cause of the great divergency of the population of Glasgow from the general population.

TABLE LVIII.

Percentages of Children of Non-Scottish Origin. Glasgow Proper.

Division	Number of Children of Origin as noted below in Public Schools sending returns		
	Per Cent. Foreign	Per Cent. Irish	Per Cent. English
Anderston	·68	6·61	3·39
Milton	1·16	4·29	4·90
St Rollox	·67	7·99	6·42
Dennistoun	·15	9·35	5·80
Calton, Camlachie and Bridgeton	·24	5·15	4·36
Tradeston, Gorbals and Hutchesontown ...	8·18	3·72	3·08

This table does not of course represent the absolute percentages of non-Scottish children in the above named divisions. Practically the whole of the children attending Catholic schools are excluded. The percentage of Irish school children in each division is really much higher. The above table merely shows the proportion in the public schools sending returns. The table serves its purpose as showing the large Irish element in the public schools of Glasgow—an element which, from the results of the analysis of the colour characters of Irish school children in Glasgow, tends to make the hair colour distribution of the western city darker than the remaining Scottish population. The school children of Irish origin have on an average 2 per cent. more of the dark-haired class (boys) and about 8 per cent. more in the girl population. A distinctly greater proportion belong to the jet black class among the Irish population, about 4 per cent., compared with $1\frac{1}{4}$ per cent. in the Scottish population. Although a greater proportion of the Irish population observed, compared with the general Scottish population, has blue eyes, this class does not appear in excess in any of the populous centres except Partick. Partick was not included nor was Govan in the investigation as to the number of school children of non-Scottish origin—an omission which the author regrets he made when the Glasgow teachers were invited to send the additional returns. Further work is contemplated on the Glasgow returns and an additional return is expected from many of the large Catholic schools. These schools have an attendance of about 20,000 children whose colour characters have not yet been observed. A very large number of these children are of Irish origin and a knowledge of their colour distribution will be useful. Of course since these children were not included in the present survey, they do not contribute to the divergency found for Glasgow.

The results of this subsection show that children of Irish origin clearly affect the nature of the distribution of colour in Glasgow. They tend, as the Scoto-Keltic and the foreign populations do, to create an excess of dark hair and jet black hair. The Irish population does not appear to affect the eye colour distribution of Glasgow sensibly. It may however do so. Other factors which have not yet been discovered may be operating to obscure the effect of the Irish element on the distribution of eye colour in the western city.

The association of excess of dark hair, jet black hair, blue eyes and light eyes with the Scoto-Keltic and Irish populations is a striking feature in these results. The results but confirm the common origin of the two peoples—their association as determined by language, by history and by tradition.

IV. *Summary of this Section.* (1) The general analysis reveals Glasgow to diverge largely from the general population both in hair colour and eye colour.

(2) Further analysis shows the divergency to be due to excesses of the medium and dark haired classes and the medium and dark eyed classes, and to defects of the fair-haired and blue-eyed classes.

(3) Analysis of the divisions into which Glasgow is divided brings out the fact that the excesses are not uniformly distributed over the city. No excess of the fair-haired class appears in any quarter of the city, but certain districts, St Rollox (♂), Dennistoun (♂), and the western suburban area (Paisley) have about the average proportion of this class. Milton, the Cowcaddens district, is the only one showing excess—a slight one—of the red-haired class. Excess of medium hair in varying

proportions occurs in every district of the city. In St Rollox, Dennistoun, Calton and Bridgeton, the excesses are not so marked in the boy population. Excess of dark hair is characteristic in a marked degree of Anderston and Tradeston, Gorbals and Hutchesontown. In other densely populated centres the girl population also shows excesses of this class. Jet black hair is in excess in the Tradeston group. Blue eyes is in excess only in the Partick group; light eyes in Anderston; medium eyes in Dennistoun and the Bridgeton and Tradeston groups; dark eyes in Anderston, Milton, Govan and the Tradeston group.

(4) The environs of Glasgow diverge in a much less degree from the general population. The population is not so dark as in the city.

(5) The deficiencies in the blue-eyed and fair-haired classes are due to the presence of a complex group which, with a darker colour specification, creates deficiencies in these classes. This complex group includes Highland, Irish, and foreign populations.

(6) It cannot be said from the data whether these classes (fair hair; blue eyes) are less fitted for town life or whether this theory would account for any of the low percentages of these classes. The low percentages are on the other hand explained by the presence of the darker Scoto-Keltic and non-Scottish elements.

(7) The Scoto-Keltic, Highland or Gaelic speaking population appreciably affects the distribution of colour and helps to explain excesses in dark hair and light and blue eyes.

(8) The Irish population, a very large one, also helps to explain the large excesses in dark and jet black hair and probably light eyes where they occur.

(9) The foreign element helps largely to explain why Tradeston and Gorbals diverge so widely from the rest of the population. The presence of other non-Scottish groups in this part of the city is probable.

(10) The country north-east and almost contiguous to Glasgow might contribute in some degree to excess of dark eyes, since these parts (Stirling, Perth, etc.) have an excess of this class in their own populations. The greater fertility of the lower classes, and of the dark-eyed portion particularly, might contribute to explain the excess of this class.

(11) Excess of medium hair and medium eyes cannot be accounted for by the presence of a Scoto-Keltic element or of a non-Scottish element or by the migration of excesses of Scottish members of these classes from rural districts to the city. Excesses of these classes are not found to any extent outwith densely populated centres.

(12) The excesses may be due to blending of fair and dark populations or to greater fertility of the medium classes, or to both these causes.

(12) *Comparison with other Data.*

I. *Scottish Data.* (*a*) *East Aberdeenshire Children in* 1896. The only data of a similar character with which any of the results of the present survey can be at all compared are the East Aberdeenshire results of 1896 published in a preliminary paper by the author in 1897*. Owing to slightly different ranges in some of the classes however the results are not directly comparable, as printed, with the results for East Aberdeenshire in 1903, when the general pigmentation survey was carried out. Fortunately in 1896, the teachers were asked not only to record the colour with reference to the classes then adopted but also to note where possible, and always if in doubt, the probable sub-class from a series of stated sub-classes, similar to Broca's scale. Thus the author has been able to retabulate where necessary the results of 1896 and, as far as possible, place the children in the classes as specified in the analytical tables of the present survey. The first survey, it has been found, had a wider range of medium and a slightly wider range of red. With respect to the eye classes, the blue and light-eyed class of 1903 corresponds pretty closely to the light-eyed class of 1896. The following table (Table LIX.) shows the relative differences in the classes between the two sets of observations. To be more specific, the table shows the difference per cent. (or d) in each class compared with the probable error of the percentage difference, that is, compared with

$$E_d = 67{\cdot}449\sqrt{\frac{pq}{m}+\frac{p'q'}{n}},$$

where in this formula, $p=\frac{y}{N}$; $q=(1-p)$; $y=$ observed frequency of the class in

TABLE LIX.

Relative Difference between East Aberdeenshire in 1896 *and* 1903. (*Boys and Girls.*)

Colour	$\frac{d}{E_d}$
Hair:	
Fair ...	1·77
Red ...	−2·05
Medium ...	−6·79
Dark ...	6·28
Eyes:	
Light ...	6·29
Medium ...	−1·74
Dark ...	−3·78

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* Tocher: *Trans. Buchan Field Club*, Vol. IV. pp. 137—152.

the first sample; m = number in first sample, $p' = \frac{y'}{N'}$; $(1 - p') = q'$; y' = observed frequency of the class in the second sample; n = number in second sample; N = total children in first sample; and N' = total children in second sample.

The negative sign indicates that the proportion of the class considered was less in 1903 than in 1896 and the positive sign that it was greater. The above results seem to indicate that the school population of East Aberdeenshire became darker haired to an extent which must be reckoned significant, and lighter eyed to an extent also significant in the eight years' interval. Making allowance for any difference in method of observation, and comparing parish with parish, the results are however very similar. The difference lies chiefly in the results from the two towns in the division, Peterhead and Fraserburgh.

(β) *Scottish Adults—The Insane.* The colour results of the survey of asylums in Scotland are not directly comparable, since the observations were made on adults and since the group is a selected one and is not truly representative of the general population. All one can do is to note in a general way the agreement or otherwise of the two sets of data. The author has not found it possible to spare the time to estimate from the juvenile data the probable distribution of the ordinary adult population in each division or to deal in further detail with the colour characters of the insane. Moreover it seems more desirable—more satisfactory—to wait until the adults of the normal population are directly surveyed. Instead of the promised detailed comparison between the two sets of data, it seems sufficient to point to the leading features. Both sets of data agree in showing less divergency in densely populated parts. The excess of dark hair in the west found for the asylum population has been amply confirmed by the results of this survey. The region of excess of dark eyes in the asylum population has proved to be the same region for the general school survey. Perthshire, Stirling and Forfar are the counties constituting this region. The excess of medium hair is in both associated with density. The proportions of fair hair and red hair are small compared with the juvenile population. Excess of light eyes is somewhat similarly distributed, but is not so much south-west as the juvenile distribution. The region of excess of red hair is quite the same. Briefly, while it would be useless to compare the relative frequencies of the two sets of data for the reasons already stated, still when the local class frequencies of each set are compared with each set's own general population, they show on the whole the same significance. It has been shown that the colour distribution of the insane population as a whole cannot represent the general distribution of the sane in one important particular, namely, in the frequency of the light-eyed class. Regions of excess of insanity from the general average are associated with regions of excess of light eyes, thereby increasing the proportion of light eyes in the general insane population beyond the expected amount for the general adult sane population*.

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* *Biometrika*, Vol. v. pp. 298—350.

(γ) *Scottish Adults—Beddoe's Observations.* The figures of the pioneer observer Dr Beddoe are useful, indicating as they do the predominant classes in various localities in Scotland. The samples of the population observed by Beddoe are usually small and in many cases they are too local to give an idea of the distribution of the surrounding area. His classes do not all correspond to those of the present data, and since adults and not children were observed by him one is farther debarred from attempting to compare directly the relative frequencies of his classes in various localities with those from this survey. The proportion of red hair generally found by him appears to be slightly higher than that found by the teachers of Scotland among the children. The excesses however appear in the same districts. He shows excess of dark hair in the same western regions of the country. The proper time to enter into a discussion of Dr Beddoe's results is when a survey of the colour characters of the adult population has been completed and the results tabulated and analysed.

II. *Foreign Data.* (α) *The Actual Data.* The results of this survey will now be compared with the results of the surveys of the colour characters of children which have been carried out in Germany, Switzerland and (partially) in England, and with the results of the surveys of the colour characters of the adult populations of Sweden and Italy (military data). The following table (Table LX.) gives the percentages of the classes in each of the countries named, the school figures for Scotland being given alongside for comparison.

TABLE LX.

Authority	Country	Nature of Population	Hair				Eyes		
			Fair	Red	Medium	Dark	Light	Medium	Dark
Virchow ...	Prussia	Children	72·4	·3	26·0	1·3	42·9	32·6	24·5
Beddoe ...	Switzerland		52·9	2·9	38·9	5·3			
Retzius ...	Sweden	Adults	75·3	2·3	21·6	·8	66·7	28·8	4·5
Livi ...	Italy	Military	8·2	·6	60·1	31·1	10·3	20·6	69·1
Ammon ...	Baden	Adults	41·6	1·7	38·6	18·1	64·4	22·9	12·7
Tocher ...	Russian Jews in Glasgow	Children	5·1	1·2	33·4	59·7	19·8	21·1	59·1
Pearson ...	England	Boys	33·5	4·1	34·0	28·4	41·5	37·0	21·6
Tocher ...	Scotland	Boys	24·95	5·49	43·28	26·28	44·97	32·72	22·31
,, ...	,, ...	Girls	27·43	5·09	40·87	26·62	45·18	32·06	22·76

(β) *Comments.* The first fact worthy of notice is that Scotland occupies an intermediate position between the extreme northern race (Germany) and the extreme southern one (Italy) in the matter of pigmentation. The northern German race has about 72 per cent. of the fair-haired class; the Italian race about 60 per cent. of the brown-haired class and 31 per cent. of the dark-haired class. Scotland has about equal proportions of fair and dark; about one-fourth of the school population is either fair-haired or dark-haired; the remaining belong to intermediate classes which include the shades of brown and red. Now if a pure race of the blonde type is defined as meaning a population which has been isolated and has bred within itself in an environment unsuitable for the production of hair pigment for a sufficient length of time to ensure that every individual will be fair-haired, it is obvious none of the northern races are pure races of the blonde type. They have relatively large sections in their respective populations which are pigmented. Similarly if by a pure race of the dark-haired type is meant a population which has bred within itself in an environment suitable for the production of hair pigment for a sufficient length of time to ensure that every individual was uniformly pigmented dark, it is clear the southern Italian race is not a pure race of the dark-haired type. The Italian people are largely of the brown or intermediate type (about 60 per cent.); 31 per cent. or nearly one-third are dark; about 8 per cent. are fair. If all the races of mankind were uniformly pigmented or non-pigmented, hair colour would cease to be one of the tests of race. But this is not the case and the problem is: how far can one use colour as a test of race or of racial purity? One must in the first place consider whether in conjugal unions between the fair and dark types blended or exclusive inheritance holds, or whether both exist. It is clear from observation that blended inheritance does exist for fair and dark hair colours, the shades of brown being the blend. What is wanted is a measure of the blended inheritance in this case. From observation it is possible that exclusive inheritance exists in the case of red hair. But the main point here is that, in hair colour, one has a problem in blended inheritance. Now granting equipotency of the two types, fair and dark, and random mating with respect to hair colour as well as other forms of mating as probable, and it is obvious that varying proportions of fair, dark and the shades of brown hair will occur in the population of a country according to the proportions of the fair and dark types originally settling in that country. Is anything known of an exact nature as to the distribution of colour in the offspring of fair and dark parents, i.e. of parents one dark and one fair? Insufficient data exist to show the exact nature of the distribution. A large number of carefully made observations are required. Individual cases can be cited. (A) Dark-haired, and (B) fair-haired, have a family of five. One is fair, one is dark, three are medium. All are children, but the oldest, classed medium, is getting darker and will probably be dark. To be accurate one must compare the colour of the parents *when they were children* with the colour of the offspring *as children*; or the colour of the parents with the colour of the offspring *as adults.* Can it be said that the most probable distribution of colour in the offspring of such parents, granting blended inheritance and equipotency in determining pigment, is, in say a family of four, 1, 2, 1; one fair-haired, two medium and one dark-haired? The object of science is to give a shorthand description of the facts. In this case the expanded binomial $(\frac{1}{2}+\frac{1}{2})^2$ is put forward tentatively as the shorthand description. If true it is a problem like determining the number of times two heads, one head and no heads, will turn up in spinning two coins together. The most probable distribution in this case is, 1, 2, 1. Can hair colour in Scotland be cited as an example of this simple binomial distribution, similar to the Mendelian example in the crossing of peas? This has to be determined. What the writer wishes to lead up to is this. In Scotland the distribution of colour is roughly, 1 fair, 2 mixed, and 1 dark. Is it fair to infer that the original elements of the Scottish population were fair-haired and dark-haired races in approximately equal proportions? Proof is wanting but the distribution is suggestive. From our knowledge of the distribution of eye colour in Scotland, it is unlikely that although there were fair-haired and dark-haired races, the two elements were entirely blonde and brunette—the blue-eyed fair-haired type, and the dark-eyed dark-haired type. It cannot be shown from the data what proportion of the *dark-haired* element was of the brunette type or what proportion was of the type found in the Gaelic speaking population, the *blue or light-eyed dark-haired* Keltic type. Who were our ancestors of the brunette type? Were they of the Mediterranean or Danish type or both? The fair-haired element probably was made up of the blonde type, Scandinavians and others of Germanic stock who, history tells us, came to our shores in bygone centuries and who fought, struggled, settled and made Scotland—the Scotland of the dark-haired Kelt—their home. Together with the darker elements they may have united and appear to be now uniting to form a blend—the Scottish type—one which in physical characters has proved itself vigorous and which, considering mental characters, has been at least relatively as productive of men of ability as any in the British Isles.

III. *The Data bearing on correlation, and comparison with similar data.* (*a*) *General.* Hitherto, throughout the entire course of this investigation, the author has been considering hair colour and eye colour separately—taken one at a time. It is obvious however that an account of the colour characters of the Scottish children would be incomplete which did not include an investigation on the two taken together as found occurring in each individual.

It is one of the disadvantages of a private investigation as compared with an official one carried out by a Department of the State, that an adequately paid staff is not available to tabulate the enormous mass of data, the complete analysis of which is necessary before a full account can be given of all the facts which flow from the results and which lie hidden until the tabulation has been made. Although the author has been continuously engaged in the tabulation and numerical treatment of the returns so kindly made by the teachers voluntarily more than four years ago, he has been able only to complete the investigation in so far as it refers to the separate colour characters. The large mass of data bearing on fraternal and other relationships lie practically untouched. The tabulation of the combinations of the two characters has still to be made, except for one or two districts. The author has complete confidence that not only will he be able to get the funds necessary for clerical assistance to tabulate these important data, but that he will be personally given sufficient time to do the work. The correlations between hair and eye colour when such data are tabulated and the values of the correlations evaluated for each locality will be of great value. Not only will the predominant types in each district be determined but the relative homogeneity of each group will be accurately ascertained. Again, there are the colour characters of groups of families as revealed by surnames to be considered. A tabulation and analysis of the colour characters of surname groups for each surname would show whether they were really associated, like family groups, or were merely samples of the general population. The degrees of resemblance of brothers and sisters would be determined on numbers hitherto undealt with and would confirm or otherwise the measures found from the numerically smaller English data. Finally, the degrees of resemblance between the various kinds of cousins, an investigation suggested to the author by Professor Karl Pearson, await determination*, and the determination cannot be made until the almost overwhelming mass of data bearing on cousinships has been also tabulated.

(β) *Comparisons.* The correlation between hair and eye colour has been determined, the contingency method being used, for one Scottish group, namely, 19,279 school children of the city of Aberdeen, and also for 1000 children taken at random from the entire pigmentation data. The following two tables give respectively (Table LXI.) the results of the observations of hair and eye combinations in the city of Aberdeen, and (Table LXII.) the values of the contingency coefficients. The author's results for other Scottish populations and those from British and continental returns are given alongside for the purpose of comparison.

TABLE LXI.

Hair and Eye Table. 19,279 *Children in the City of Aberdeen.*

Hair.

		Fair	Red	Medium	Dark	Jet Black	Totals
Eyes.	Blue ...	1105	131	885	348	1	2470
	Light ...	2285	405	2434	851	9	5984
	Medium ...	1208	360	3242	1601	29	6440
	Dark ...	366	209	1621	2094	95	4385
	Totals ...	4964	1105	8182	4894	134	19279

These results show, if it is a mark of racial purity of any race to have its individuals all of one hair colour and of one eye colour, that the Prussian school children are relatively more homogeneous than the Scottish school children, and that the latter in turn are more homogeneous than the British schoolboys generally, since the value of the correlation is lowest in the case of the Prussian children and highest in the case of the British schoolboys. It may be here noted that if two races, one of the blonde type and one of the brunette type, were present in a population in equal proportions, the degree of correlation between hair colour and eye colour would be equal to unity. On the other hand, (1) the

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* The author intends to hand over the classified data on cousinships to Professor Pearson as soon as they have been abstracted and tabulated.

TABLE LXII.

Correlations. Hair and Eyes.

Population	Contingency Coefficient	Returns by	Reference
Scottish Children, General, 1903	·3453	J. F. Tocher	This Memoir
Scottish Children, East Aberdeen, 1896 ...	·3802	"	"
Scottish Children, Aberdeen City, 1903 ...	·3361	"	"
British Schoolboys	·4203	K. Pearson	*Biometrika*, Vol. III. p. 461
Prussian Children	·2714	R. Virchow	" "
Jewish Children	·3381	"	" "
Adult Scottish Population	·3673	J. F. Tocher	*Biometrika*, Vol. v. p. 339
Male Asylum Inmates	·3039	"	" "
Female Asylum Inmates	·2994	"	" "
Swedish Conscripts	·2495	G. Retzius	*Biometrika*, Vol. III. p. 461
Italian Conscripts	·3091	R. Livi	" "
Baden Conscripts	·3540	O. Ammon	" "
Mean of above values	·3312		

more this population in time and through intermarriage was thoroughly crossed, or (2) the nearer this population came to consist of members entirely of either race, the smaller would be the value of the correlation and the nearer it would approach to zero. Looked at from this point of view, a large value for the correlation would mean heterogeneity in that population and a small value greater homogeneity.

Judging from the above results, the correlation between hair and eyes does not appear very close in any of the countries. With more local groups it is probable that in countries like Prussia and Italy less association would be found.

In the further investigations on the data of this survey, it will be interesting to find what values the correlation coefficients take in the various districts; particularly (α) in those where one type has been found to be predominant, and (β) in those sparsely populated parts where two diverse types were found.

(13) *Summary of the Results.*

I. The general result of the Pigmentation Survey of School Children in Scotland shows that, of the 502,155 children surveyed, about one-fourth are fair-haired, one-fourth dark-haired, and nearly one-half belong to two intermediate classes embracing the various shades of brown or medium and red hair. The proportion of the brown or medium class in the boy population is about 43 per cent., and in the girl population 41 per cent. The class embracing the various shades of red hair constitutes about 5 per cent. of the population. In the dark-haired group there are two classes—a large class with dark brown hair approaching to black, and a small class with jet black hair. This latter class constitutes only $1\frac{1}{4}$ per cent. of the total population. The girl population contains a higher proportion of the fair-haired class than the boy population, over 27 per cent. as against 25 per cent. There is a correspondingly less proportion of the medium or brown-haired class in the girl population. The cause of this difference is not quite apparent. It should be remembered that the children surveyed are those of school age—a fairly wide range, from 6 to 18—and that hair colour in children gets visibly darker as the children get older. If the children were classed according to age and their colour characters tabulated, it would be ascertained whether or not the difference was due to an earlier darkening in hair colour among the boy population, or whether the boy population was really significantly darker in hair colour from infancy than the girl population. From the results of observations of the physical characters generally of both sexes, a really significantly darker boy population from natural causes is improbable. It should moreover be remembered that, in determining hair colour, boys and girls are not judged exactly under the same conditions. Hair colour in girls is generally judged from long tresses. These are usually absent in boys, whose hair colour is judged from the shorter mass. Besides, girls' hair frequently shows extreme variety of tint from tip to root. Another possible explanation is the stimulus given to the increase of pigment by hair cutting in the boy population. This explanation requires verification from observations, (α) on a population of children in which the conditions are the same, and (β) on the adult population.

The results of the observations on eye colour show that over 22 per cent. (nearly one-fourth) of the school children of Scotland have dark brown or dark eyes, and over three-fourths of the population possess blue, light or medium eyes. About 15 per cent. possess pure blue eyes, 30 per cent. light eyes, and about 32 per cent. (nearly one-third of the population) possess eyes of the mixed type —the varieties classed as medium eyes.

Comparing these general results with the results of similar surveys in foreign countries, it is seen that they differ markedly in many respects. In Northern Europe, between the same latitudes as Great Britain lies from Frankfurt, Prague and Cracow in the south to Christiania, Stockholm and St Petersburg in the north, one finds a heterogeneous population in which the fair-haired class predominates. In Prussia alone, 72 per cent. or nearly three-fourths of the children are fair-haired. In Sweden, a similar proportion of the adults are fair-haired. In Schleswig, 80 per cent. of the children are fair-haired; in Saxony, 69 per cent. Germany, south of Frankfurt and Coburg, is distinctly darker than the northern and larger portion. But even in South Germany the proportion of the fair-haired class far exceeds that found in Scotland. In Alsace and Lorraine the proportion is 47 per cent.; in Baden 58 per cent.; in Würtemberg 62 per cent.; and in Bavaria 54 per cent. The difference in the distribution of eye colour is not so marked. Prussia is somewhat similar to Scotland in its eye colour, the proportions being in Prussia 43, 33 and 24 as against 45, 33 and 22 in Scotland for light, medium and dark eyes respectively. Germany as a whole has a significantly greater proportion of dark eyes than in Scotland, 32 per cent. as against 22 per cent. Scotland does not resemble Italy in any respect, except that in both medium is the predominant class in hair colour. In Italy, however, the proportion is significantly greater, 60 per cent. as against 43 per cent. in Scotland. Nowhere on the Continent does one find a distribution of hair colour similar to Scotland. It remains to be seen, when observations are made on English, Welsh and Irish children, in what respects these will differ from the results for Scottish children as shown by this survey. The difference between Pearson's series of 4000 children and Scottish children is not very great.

II. The results of this survey show that the distribution of colour is by no means uniform throughout Scotland. On the contrary, there are well-defined areas where the proportions of the various classes exceed quite significantly the proportions which would occur if the population were as evenly distributed throughout Scotland as, say, the grain of a cornfield is sown by the farmer. In this example, the distribution of the grain is not *absolutely* uniform, but the farmer succeeds in preventing excessive deposits of grain in one part and meagre deposits in another. An enumeration of the number of seeds in each square yard, and an analysis of the numbers would show that the *intention* had been to make a uniform distribution. No such uniform distribution of the population of Scotland is found when the population is considered in sections as represented by the various colour classes. This is quite apart from the density of the population, which is well known to be very far from being uniform. The *proportions* of the various classes quite exceed in the expected values in many localities.

Excesses of blue eyes and fair hair occur mainly in the north of Scotland and are common for both sexes to Orkney, Shetland, the isle of Lewis, Ross, Cromarty, Elgin, Nairn and Perth, and portions of Stirling, Forfar and Fife; also to Ayr and portions of Renfrew and Lanark in the west and Berwick in the east; in all representing only about 1,000,000 of the population; that is, about one-fifth of the whole population of Scotland has a significantly greater proportion than the average of the fair-haired and blue-eyed classes, the excesses being common to both sexes. In the girl population the distribution of excess of both classes is greater; it extends to a population of nearly two millions in the case of fair hair and to about a million-and-a-half in the case of blue eyes. The distribution of red hair is fairly uniform throughout Scotland. The region of marked excess for a large area is the north-east of Scotland. Isolated cases of excess occur in Sutherland and in the north-east of Lanarkshire. Excessive proportions of medium or brown hair occur in Glasgow, Govan, Dundee, and in the counties of Renfrew, Selkirk and Peebles. The excess in Leith for the boy population is also probably significant, as also the excesses in the counties of Stirling (girls), Linlithgow and Bute (boys). Excess of this class (see VII.) is peculiar to densely populated districts. Excess of dark hair is peculiar to the west of Scotland, the only eastern county showing excess of this class (boys only) being the small county of Kincardine. The counties of Inverness and Argyll, and the city of Glasgow, show excess of this class for both the boy and girl populations. Kirkcudbright and Sutherland (boys), and Renfrew (girls), also show significant excess. The west is also the region of excess of jet black hair, a small class numerically. Altogether there are only about 6000 children out of a total of over 500,000 who possess jet black hair. The excess is common to both sexes in the counties of Perth, Inverness, Ross and Cromarty. Caithness (boys) and Argyll (girls) also show significant excess. Excess of blue eyes has already been stated to be common to the north. Significant excess of light eyes is common to Argyll and Dumbarton in the west and to Leith in the east. Kincardine and Kirkcudbright both show significant excess of this class in the girl population. Significant excess of medium eyes is peculiar to the great cities, Glasgow, Aberdeen (girls), Leith (girls), and Dundee (girls); and to the county of Lanark generally. Significant excess of dark eyes is also peculiar to the great cities, Glasgow, Edinburgh and Dundee. The county of Forfar shows significant excess for the girl population.

III. Many parts of Scotland quite resemble the general population in hair colour and eye colour. These parts are usually densely populated. Notable exceptions occur. Glasgow is the striking example. The presence of non-Scottish elements and of excess of the Highland element makes Glasgow unrepresentative. The populous East-Midland division is most representative of the general population in hair colour. The populous counties, Forfar, Fife, Stirling and Dumbarton, and the city of Edinburgh are fairly representative of the general population. The counties which diverge largely in hair colour from the general population, and have therefore non-representative populations, are Ross, Cromarty, Inverness and Argyll, the divergency being common to both the boy and girl populations. The divergency in the case of Argyll is due to excess of dark hair and jet black hair, and in the other cases to excesses of both fair and dark. The divergency in the north-east of Scotland is due to excess of red hair and fair hair. The seaboard on the west coast from Sutherland to Mull is highly divergent, due to significant excess of dark hair and jet black hair. In eye colour, the Southern and South-Eastern divisions are the most representative; the North-Western and South-Western the most divergent. Orkney, Shetland, Sutherland, Ross, Cromarty, Inverness, Elgin, Nairn and Forfar all diverge because of excess of blue eyes; in Sutherland and Forfar excess of dark eyes also contributes to the divergency. In the cities of Glasgow and Dundee, the divergency is due to excess of medium and dark eyes; in Aberdeen to medium; and in Leith to light and medium. The counties of Argyll, Dumbarton and Dumfries in the west diverge because of excess of light eyes; and Ayr because of blue and light. The isle of Lewis diverges because of excess of blue eyes and the isles of Jura and Islay because of excess of light. These islands contribute largely to the divergency of their respective counties, Inverness and Argyll.

IV. It has been proved (see II. and III.) that excesses in the various classes, or positive differences much in excess of the expected, occur all over the country, frequently in contiguous areas, thus indicating a differentiation for each class from the general population. In measuring the degree of geographical separation or local segregation for each class, it has been proved that the blue-eyed and fair-haired classes have the greatest degree of local segregation. The segregation of these classes from the others is excessively great. Children belonging to these classes are congregated more in sparsely populated regions than in densely populated or moderately populated parts. The medium haired and medium eyed classes show the next greatest degree of local segregation. Children of these classes are congregated more in towns and in densely populated parts. The other classes all show a high degree of segregation except the red-haired class, which is almost uniformly distributed throughout the country. But for the regions of excess in the north-east of Scotland and in one or two other isolated and much smaller areas the distribution of this class would be practically uniform. This fact suggests that the occurrence of red hair (α) is independent of race, or (β) is one of the effects of blending of races, perhaps widely divergent races, or (γ) is an abnormal condition in hair colour and deserves the attention of the physiologist and pathologist. The statement of Tacitus as to the red-haired Caledonians points at least to the fact that red hair was a trait among the inhabitants of the north of Scotland in earlier times, and it is a striking circumstance that excess of this class is found in the region referred to by him.

V. It has been found that regions of excess of the dark-haired, jet black haired and blue-eyed classes are associated with regions of excess of the Gaelic speaking population. The measure of the association is given. This association was to be expected, seeing that these classes occur in excess in western counties, where the population is bilingual and where Gaelic is the mother tongue of a large proportion of the inhabitants. A typical Scoto-Kelt is therefore blue-eyed and dark-haired, but the light-eyed dark-haired type is also common in Argyll and its Isles. It will be seen later (XVI.) that there is a similar Irish type.

VI. It is proved that foreign immigrants tend to reside in the most densely populated areas in Scotland and in districts where families live in one or two rooms. The children of foreign immigrants have an effect,—scarcely an appreciable one,—on the population of Scotland as a whole, but in certain very densely populated parts they have a distinct effect. For example, it is shown that in certain divisions of Glasgow, Tradeston and Gorbals (see XVI.), the proportion of school children of foreign origin is so high as to change completely the nature of the distribution of hair colour and eye colour.

VII. It is proved that densely populated regions are positively correlated with excesses of the following classes: medium hair, medium eyes and dark eyes. The more densely populated a region is the greater will be the proportions of these classes in the population, and conversely, the more sparsely populated a region is, the smaller on an average will be the proportion of the classes just named.

VIII. It is well known that mortality is higher in more densely populated regions than others. It has been proved (see VII.) that certain classes are more characteristic of crowded areas than others. It is therefore to be expected that these classes would be positively correlated with the death rate. It is shown that an increase in the proportions of medium hair and dark eyes is associated with an increase in the death rate. This does not necessarily mean that persons belonging to these classes are less virile but simply that a large proportion of them live under conditions which are productive of a higher mortality. A direct investigation to determine whether any colour class is associated positively with a high death rate is desirable.

IX. It is shown that neither the Highland, Irish, English nor foreign elements in the population account for the high proportion of medium hair found in all densely populated regions. These elements however (excepting the English) where present, tend to increase the proportion of dark and jet black hair.

X. It is proved that the number of births per family is greater on an average in densely populated parts, and, as a consequence, that the number of births per family is greater where there are large proportions of medium hair and medium eyes. The lower classes are found in the denser centres. Thus it is likely that the medium haired, medium eyed lower classes are on an average more fertile than the remaining population. Here again a direct investigation is desirable.

XI. The main cause of the large excess of medium hair in densely populated parts probably arises from the blending of colour in the offspring of fair-haired and dark-haired persons: it is pointed out that blended inheritance exists in hair colour and what is wanted is a measure of its intensity. In densely populated areas, greater opportunities for intermixture of races occur, and it is shown (II. and III.) that in the large sparsely populated districts fair hair and dark hair, indicative of at least two different types, occur in excess, while in the urban regions these excesses mainly disappear and excess of medium hair appears.

XII. The excess of dark eyes in urban areas does not appear to be explainable in the same way. It has been suggested that exclusive inheritance in eye colour may be one of the causes of the excess in these areas. In the offspring of dark-eyed and blue-eyed parents it is possible that reversions may occur, maintaining the dark-eyed type.

XIII. The extent of the association of the colour classes geographically has been determined. One of the main results shows that as a rule medium hair is associated geographically with no other hair colour and goes to confirm the theory that medium hair is a blend. Thus it is to be expected that the proportion of this class will increase, tending to make the hair colour of the Scottish people more and more uniform. Excess of red hair is found as a rule only in regions where the proportion of dark hair is well below the average; a slight excess of fair is associated with excess of red. There is no positive association geographically of any class with light eyes. Excess of blue eyes occurs alone, but excesses of dark eyes and medium eyes as a rule occur together.

XIV. It has already been shown elsewhere by the author that where there is an excess of light eyes in the population the number of cases of insanity is above the average and *vice versa*. It is now shown here that a greater number of cases of imbecility, blindness and deafness occurs in regions where blue eyes, dark and jet black hair are in excess. It has been already pointed out (see V.) that these classes are associated with the Gaelic speaking population. A direct determination of the relationship shows that significantly greater numbers of cases of these defects occur in Gaelic speaking regions than throughout the rest of Scotland. This is most probably due to the greater rate of emigration of the fitter portion from, and the relative absence of immigration to, the Highlands.

XV. The degree of resemblance between the boy and girl populations has been determined. It is found that positive and negative differences in the boy population are mainly associated with positive and negative differences in the girl population in the same regions. The resemblance is least in the red and dark-haired classes and greatest among the medium-haired and blue-eyed classes. The resemblance is closer in eye colour than in hair colour.

XVI. Glasgow so greatly diverges from the general population in hair colour and eye colour that it has been made the subject of a special investigation. The various municipalities constituting Greater Glasgow, as well as its environs, have been included in the investigation. It is shown that the Highland, Irish, foreign elements all contribute to increase the proportion of the dark-haired classes. Tradeston and Gorbals have greater proportions of dark hair, jet black hair and dark eyes, mainly due to the large foreign element present in these populous divisions. The detailed analysis shows that the immigrants are of Russian origin and this is confirmed by direct enquiry. More than 500 Jewish children attend school in these divisions. Dark hair, jet black hair, dark eyes are the leading classes in this population. The Highland and Irish elements are found all over the city. It is shown that the Irish resemble to a great extent in colour characters the Highland population. Both contribute very largely to the excess of dark hair. Medium hair is in excess all over the city, as expected, since this class is associated with density and since Glasgow contains a greater number of persons per square mile than any other part of Scotland. The high proportions of these classes (dark and medium) cause a corresponding defect in the proportion of fair hair in Glasgow. Only in one or two divisions, St Rollox, Dennistoun, and the Paisley district, does the proportion of fair hair approach the average for Scotland. In all the other divisions fair hair and blue eyes are distinctly below the average. It cannot be said from the results of this survey whether fair-haired and blue-eyed children are less fit for town life than the other classes, but the defect in fair hair at least is quite explainable on the ground that the proportion is disturbed (α) by a darker Scoto-Keltic or Highland element, (β) by a darker Irish element, (γ) by a darker foreign element and (δ) by the effects of blending of fair and dark producing the various shades of brown classed as medium. All these contribute to the result and, taken together as a whole, are sufficient to cause the defect in the proportion of fair hair. *Entia non sunt multiplicanda.* It is probable that the country north-east and contiguous to Glasgow may contribute to the excess of dark eyes, but it is also probable, since the lower classes are more fertile, since dark eyes are associated with density, and since it has been shown elsewhere that dark eyes are associated with greater fertility, that greater fertility may contribute to produce the excess found in Glasgow.

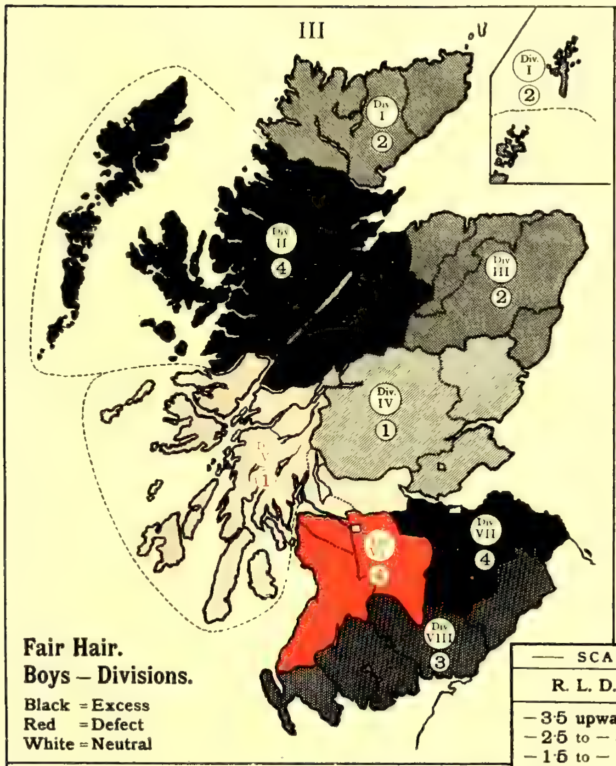
XVII. The population of East Aberdeenshire which was surveyed in 1896 has possibly become slightly darker in hair colour and lighter in eye colour in the eight years' interval. The change does not appear to have taken place in the rural districts but is more likely to have taken place in the two towns, Peterhead and Fraserburgh.

XVIII. The regions of excess and defect in hair colour and eye colour as found in surveying the Scottish insane correspond in many cases to similar regions as found by this survey. In others they do not agree. This arises mainly from (α) the fact that the insane are a somewhat selected population, (β) the fact that they are adults and not therefore directly comparable and (γ) the fact that the numbers are small compared with the numbers in this survey.

XIX. Several of Dr Beddoe's results have received confirmation, but the remarks on the Scottish insane (see XVIII. above) apply to his observations. His results are not directly comparable.

XX. The degree of association between hair colour and eye colour found from the results of this survey corresponds very closely to the values already found from other British and from foreign data.

XXI. The results of this survey point to the conclusion that there are at least five types in Scotland. (α) One whose colour characters are dark hair and dark eyes; (β) dark hair and blue or light eyes; (γ) fair hair and blue eyes; (δ) a fourth type probably a product of two or more of the foregoing possessing medium hair (and perhaps dark hair) and medium eyes; (ϵ) a fifth type, possessing red hair associated mainly with medium eyes, is also present in small proportions (about 5 per cent.) and is also probably a product of two or more of the other types. These may be named respectively (α) the Dark European type (examples of subtypes: (1) Mediterranean, (2) Danish); (β) the Scoto-Keltic type; (γ) the Scandinavian or Germanic type; (δ) the Scottish type; and (ϵ) the Caledonian type.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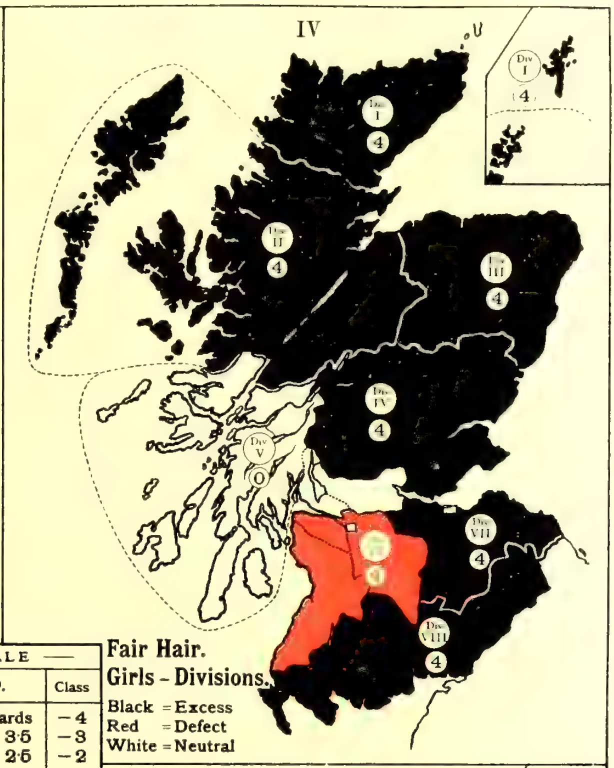
Div. I
2
Div. II
4
Div. III
2
Div. IV
1
Div. V
1
Div. VI
0
Div. VII
4
Div. VIII
3
Div. I
2

Fair Hair.
Boys – Divisions.
Black = Excess
Red = Defect
White = Neutral

SCALE

R. L. D.	Class
– 3·5 upwards	– 4
– 2·5 to – 3·5	– 3
– 1·5 to – 2·5	– 2
– 0·5 to – 1·5	– 1
+ 0·5 to – 0·5	0
+ 0·5 to 1·5	1
1·5 to 2·5	2
2·5 to 3·5	3
3·5 upwards	4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Div. I
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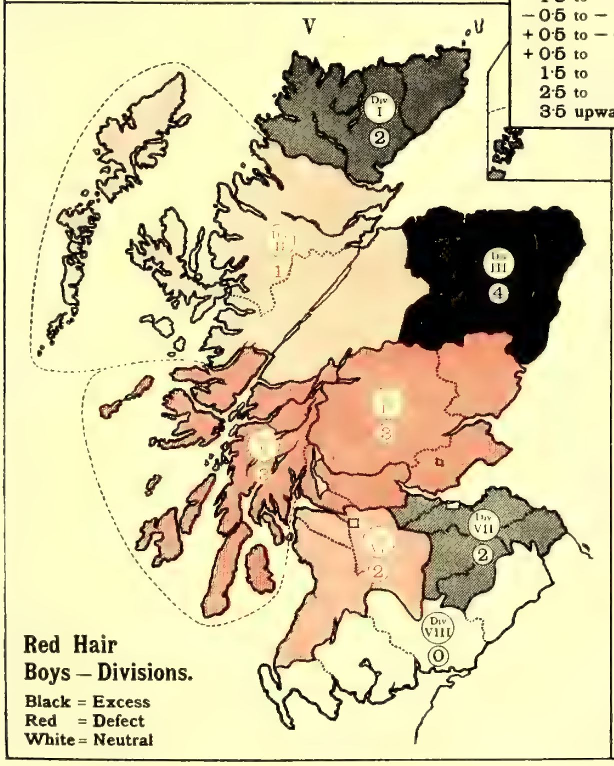
Div. II
4
Div. III
4
Div. IV
4
Div. V
0
Div. VI
0
Div. VII
4
Div. VIII
4
Div. I
4

Fair Hair.
Girls – Divisions.
Black = Excess
Red = Defect
White = Neutral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Div. I
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Div. II
1
Div. III
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Div. IV
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Div. V
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Div. VI
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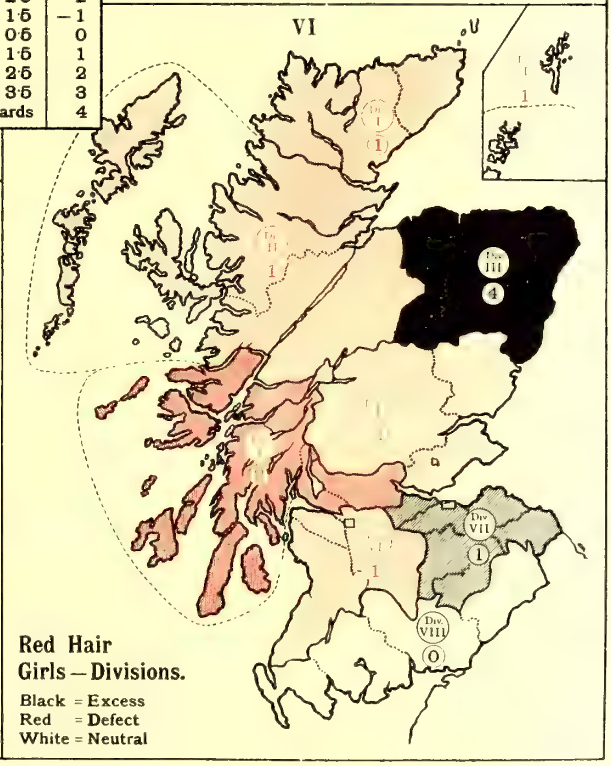
Div. VII
2
Div. VIII
0

Red Hair
Boys – Divisions.
Black = Excess
Red = Defect
White = Neutral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Div. I
1
1
Div. II
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Div. III
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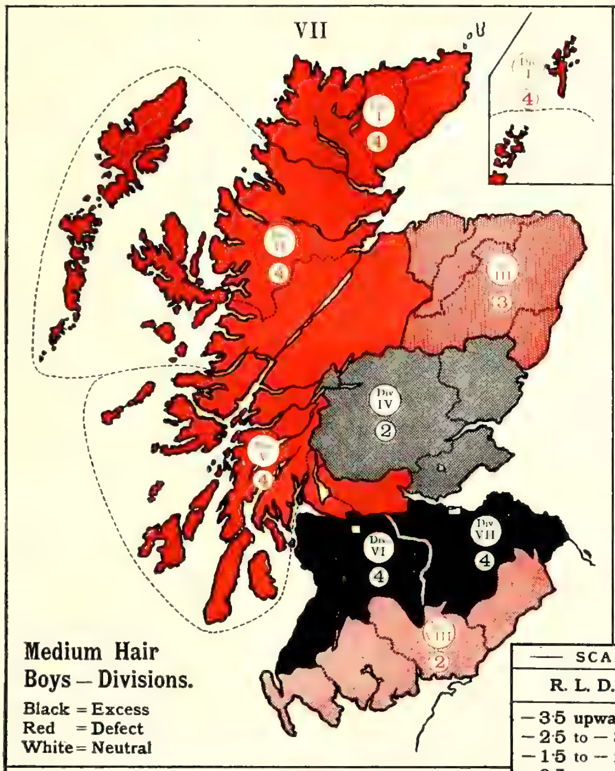
Div. VII
1
Div. VIII
0
1

Red Hair
Girls – Divisions.
Black = Excess
Red = Defect
White = Neutral


VII
Div. I
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Div. I
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Div. II
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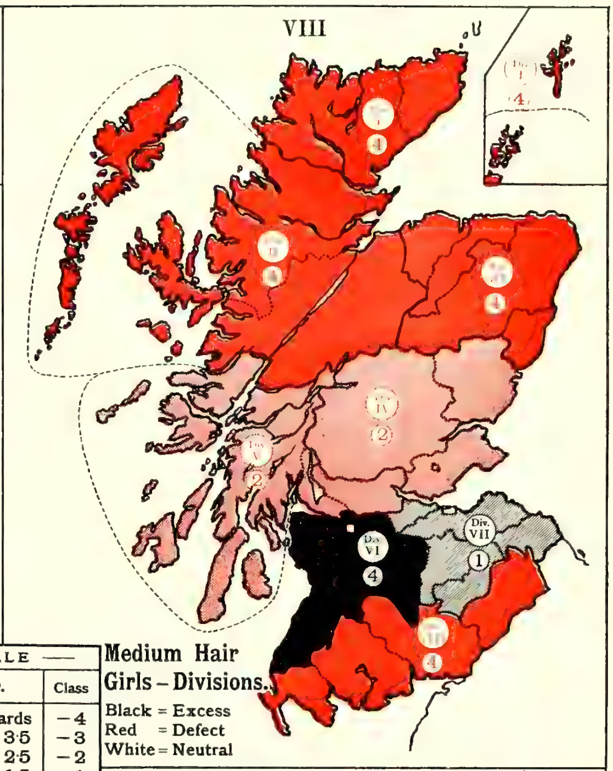
Div. III
3
Div. IV
2
Div. V
4
Div. VI
4
Div. VII
4
Div. VIII
2

Medium Hair
Boys — Divisions.

Black = Excess
Red = Defect
White = Neutral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Div. I
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Div. I
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Div. II
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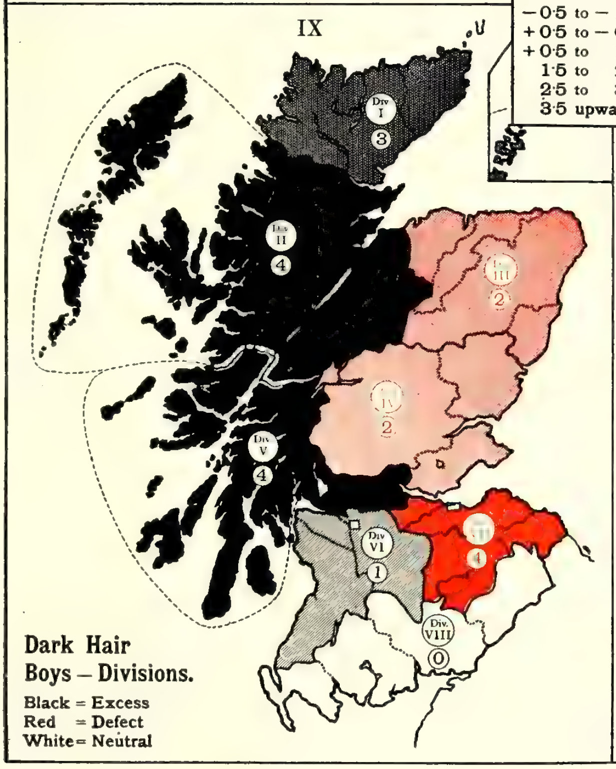
Div. III
4
Div. IV
2
Div. V
2
Div. VI
4
Div. VII
1
Div. VIII
4

Medium Hair
Girls – Divisions.

Black = Excess
Red = Defect
White = Neutral

SCALE

R. L. D.	Class
− 3·5 upwards	− 4
− 2·5 to − 3·5	− 3
− 1·5 to − 2·5	− 2
− 0·5 to − 1·5	− 1
+ 0·5 to − 0·5	0
+ 0·5 to 1·5	1
1·5 to 2·5	2
2·5 to 3·5	3
3·5 upwards	4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Div. III
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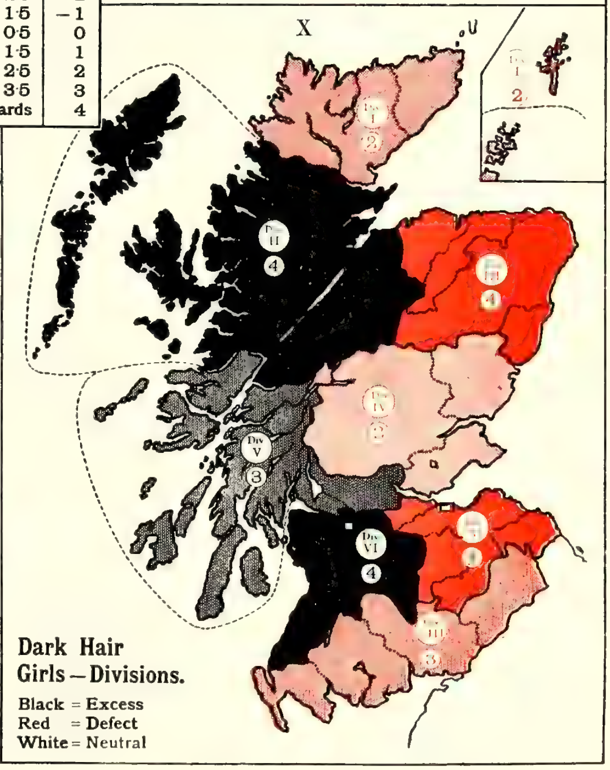
Div. IV
2
Div. V
4
Div. VI
1
Div. VII
4
Div. VIII
0

Dark Hair
Boys — Divisions.

Black = Excess
Red = Defect
White = Neutral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Div. I
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Div. II
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Div. III
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Div. IV
2
Div. V
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Div. VI
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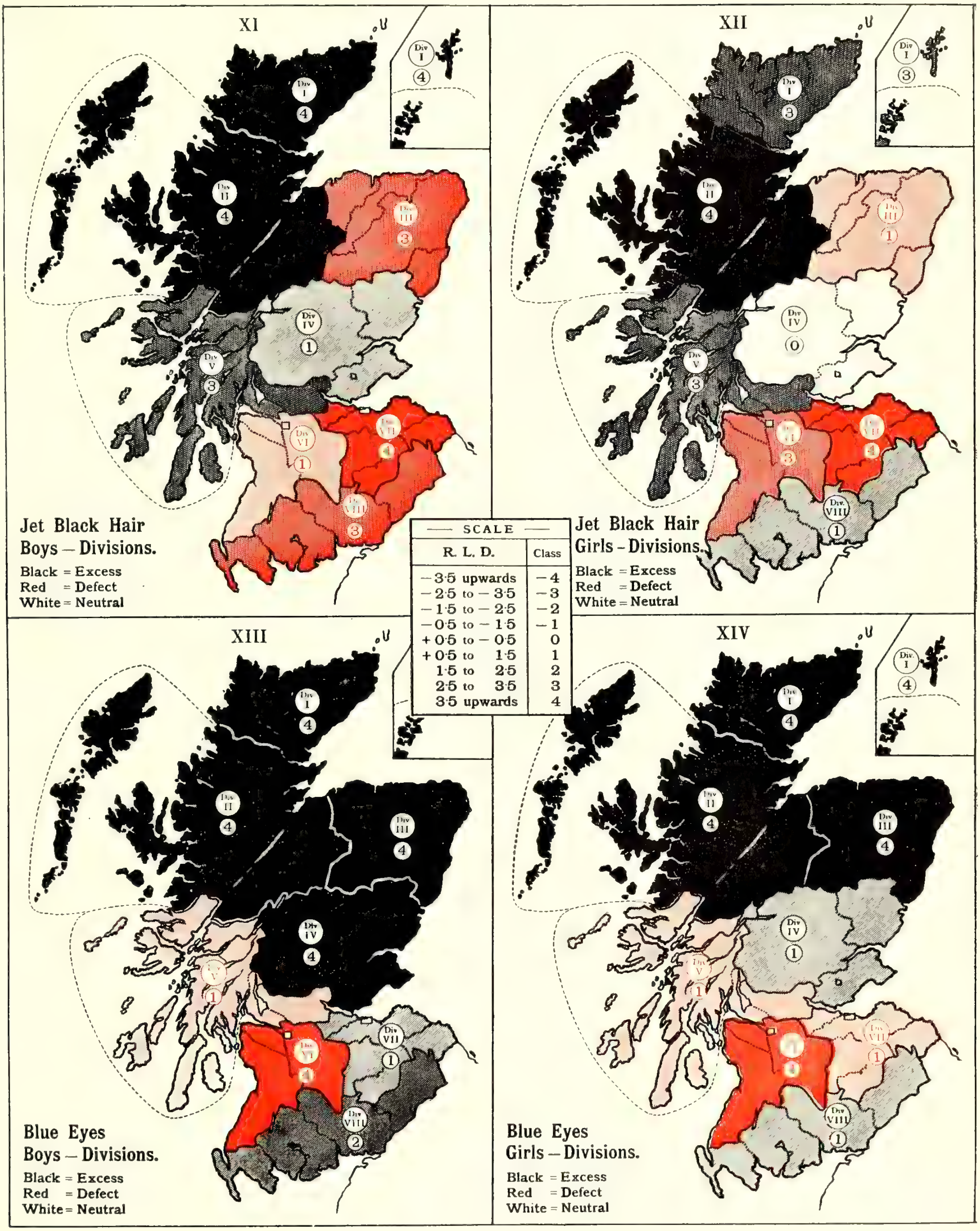
Div. VII
4
Div. VIII
3

Dark Hair
Girls — Divisions.

Black = Excess
Red = Defect
White = Neutral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Div III
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Div IV
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Div V
3
Div VI
1
Div VII
4
Div VIII
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XII
Div I
3
Div II
4
Div III
1
Div IV
0
Div V
3
Div VI
3
Div VII
4
Div VIII
1
XIII
Div I
4
Div II
4
Div III
4
Div IV
4
Div V
1
Div VI
4
Div VII
1
Div VIII
2
XIV
Div I
4
Div II
4
Div III
4
Div IV
1
Div V
1
Div VI
4
Div VII
1
Div VIII
1

Jet Black Hair
Boys — Divisions.

Black = Excess
Red = Defect
White = Neutral

Jet Black Hair
Girls – Divisions.

Black = Excess
Red = Defect
White = Neutral

SCALE

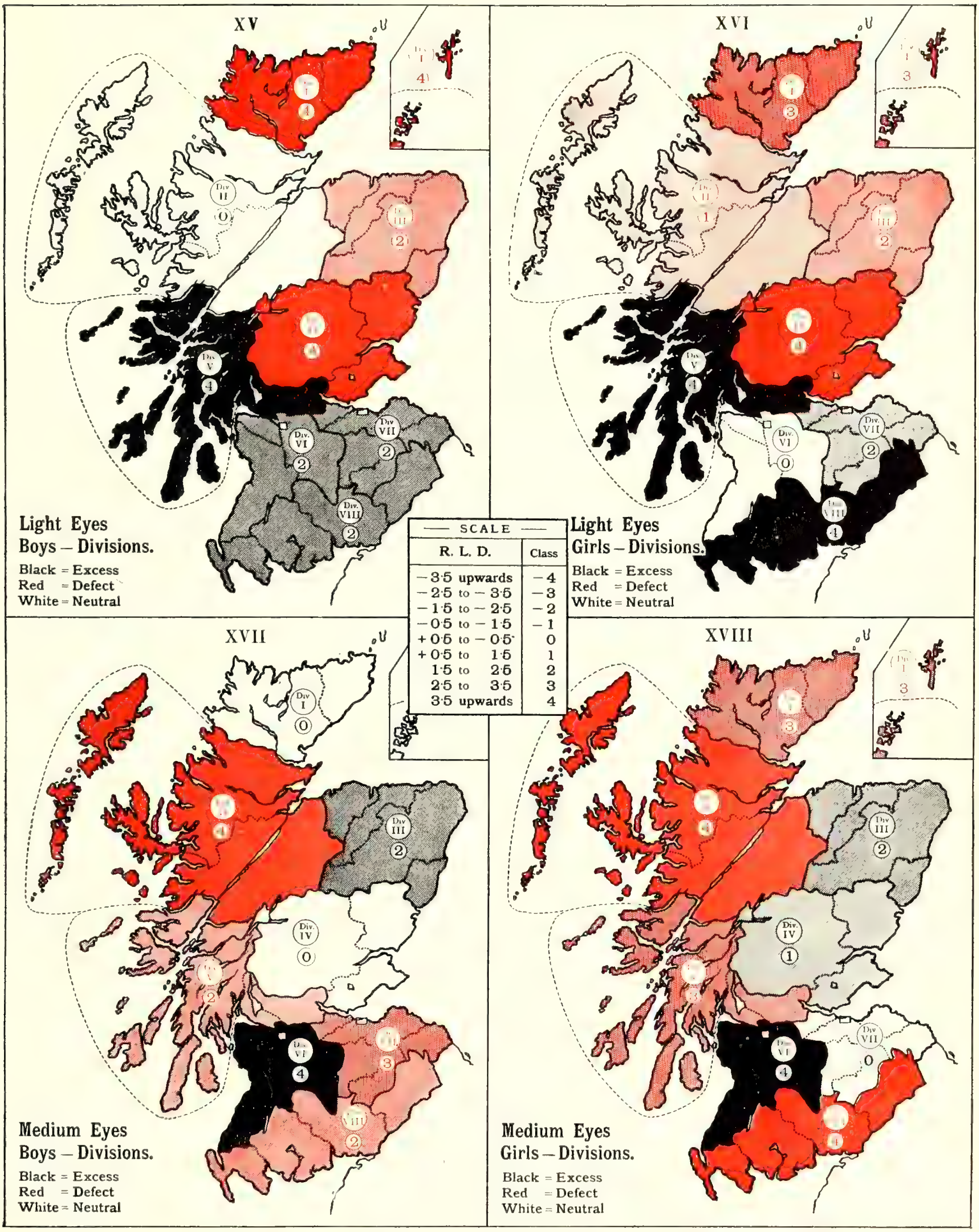
R. L. D.	Class
−3·5 upwards	−4
−2·5 to −3·5	−3
−1·5 to −2·5	−2
−0·5 to −1·5	−1
+0·5 to −0·5	0
+0·5 to 1·5	1
1·5 to 2·5	2
2·5 to 3·5	3
3·5 upwards	4

Blue Eyes
Boys — Divisions.

Black = Excess
Red = Defect
White = Neutral

Blue Eyes
Girls — Divisions.

Black = Excess
Red = Defect
White = Neutral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Div. II
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Div. III
2
Div. IV
4
Div. V
4
Div. VI
2
Div. VII
2
Div. VIII
2
Div. I
3
Div. II
1
Div. III
2
Div. IV
4
Div. V
4
Div. VI
0
Div. VII
2
Div. VIII
4
Div. I
0
Div. II
4
Div. III
2
Div. IV
0
Div. V
2
Div. VI
4
Div. VII
3
Div. VIII
2
Div. I
3
Div. II
4
Div. III
2
Div. IV
1
Div. V
3
Div. VI
4
Div. VII
0
Div. VIII
4

XV

Light Eyes
Boys – Divisions.

Black = Excess
Red = Defect
White = Neutral

XVI

Light Eyes
Girls – Divisions.

Black = Excess
Red = Defect
White = Neutral

XVII

Medium Eyes
Boys – Divisions.

Black = Excess
Red = Defect
White = Neutral

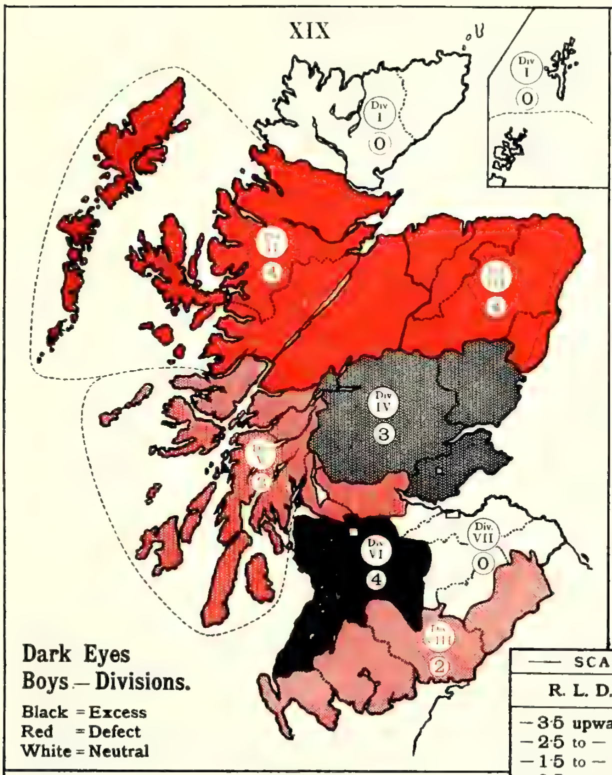
XVIII

Medium Eyes
Girls – Divisions.

Black = Excess
Red = Defect
White = Neutral

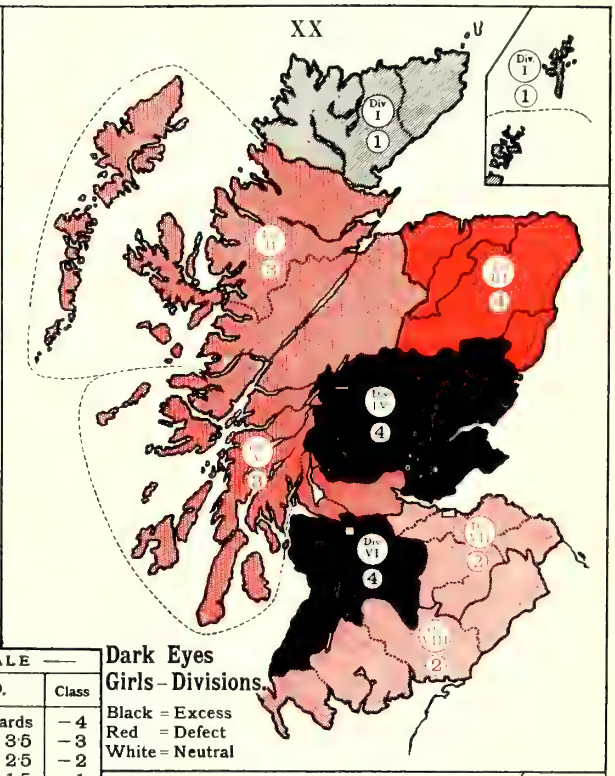
SCALE

R. L. D.	Class
−3·5 upwards	−4
−2·5 to −3·5	−3
−1·5 to −2·5	−2
−0·5 to −1·5	−1
+0·5 to −0·5	0
+0·5 to 1·5	1
1·5 to 2·5	2
2·5 to 3·5	3
3·5 upwards	4


XIX
Div I
0
Div II
4
Div III
Div IV
3
Div VI
4
Div VII
0
Div VIII
2

Dark Eyes
Boys — Divisions.

Black = Excess
Red = Defect
White = Neutral

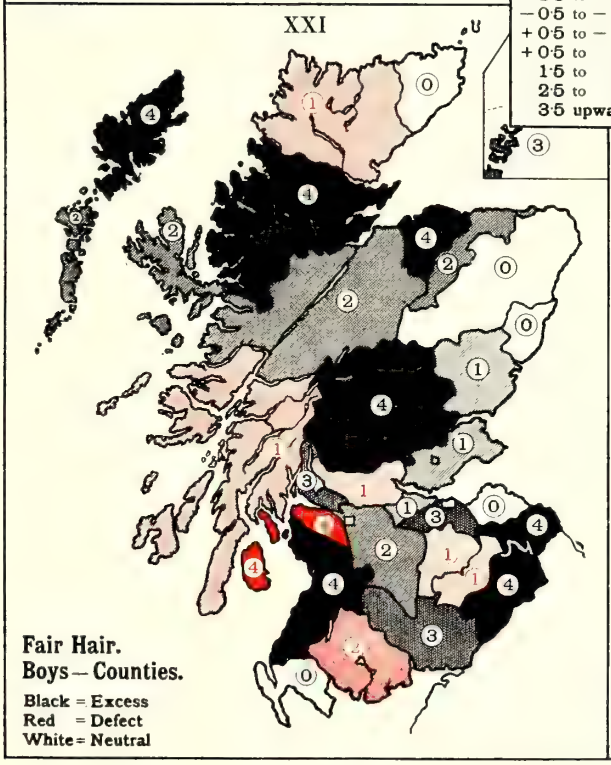

XX
Div I
1
Div II
Div III
Div IV
4
Div VI
4
Div VII
2
Div VIII
2

Dark Eyes
Girls – Divisions.

Black = Excess
Red = Defect
White = Neutral

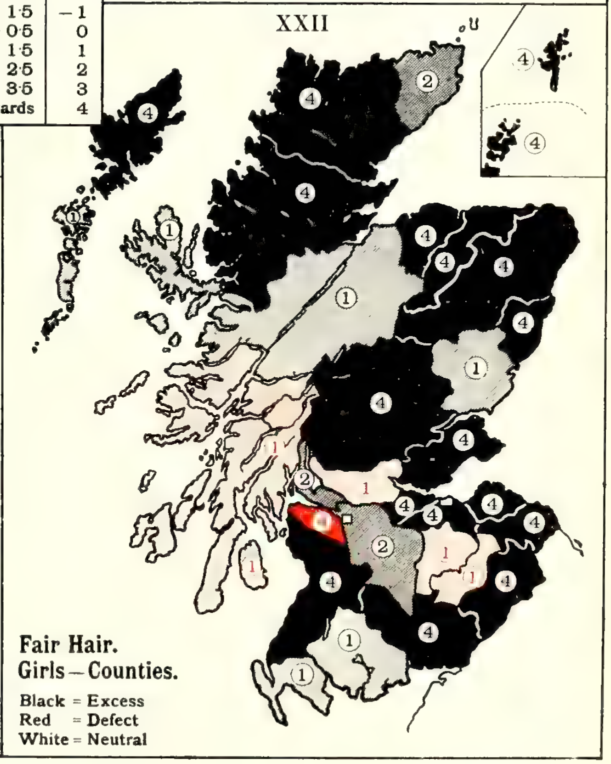
SCALE

R. L. D.	Class
−3·5 upwards	−4
−2·5 to −3·5	−3
−1·5 to −2·5	−2
−0·5 to −1·5	−1
+0·5 to −0·5	0
+0·5 to 1·5	1
1·5 to 2·5	2
2·5 to 3·5	3
3·5 upwards	4



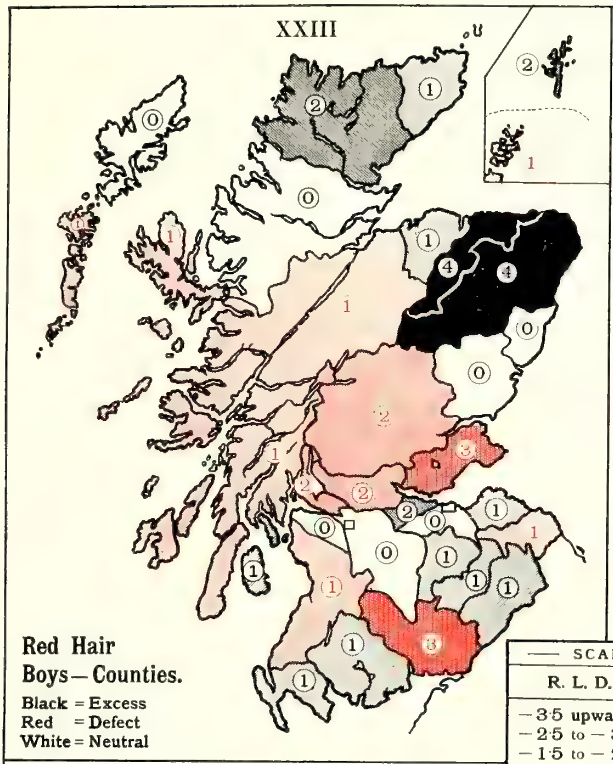
Fair Hair.
Boys — Counties.

Black = Excess
Red = Defect
White = Neutral



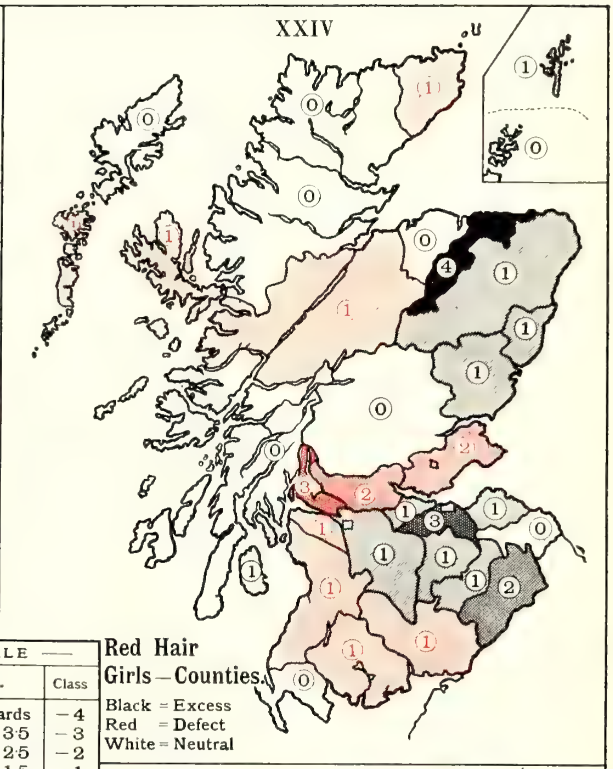
Fair Hair.
Girls — Counties.

Black = Excess
Red = Defect
White = Neutral



Red Hair
Boys—Counties.

Black = Excess
Red = Defect
White = Neutral

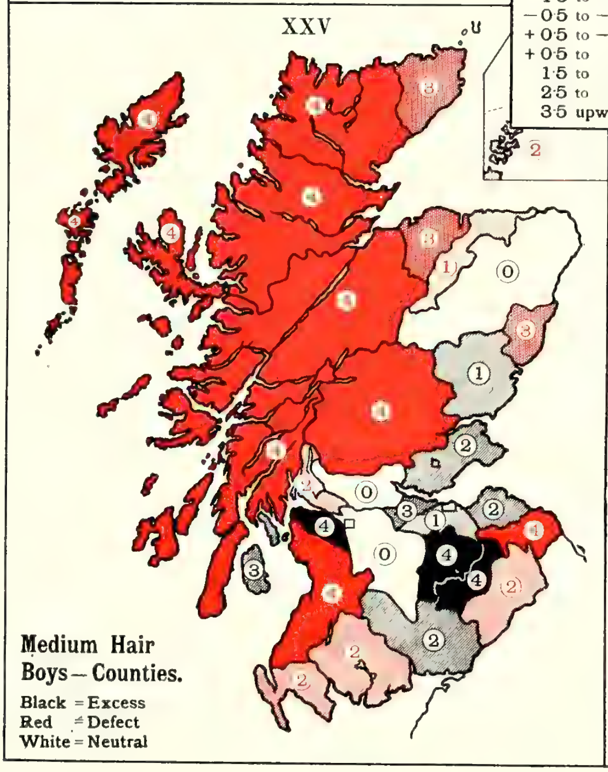


Red Hair
Girls—Counties.

Black = Excess
Red = Defect
White = Neutral

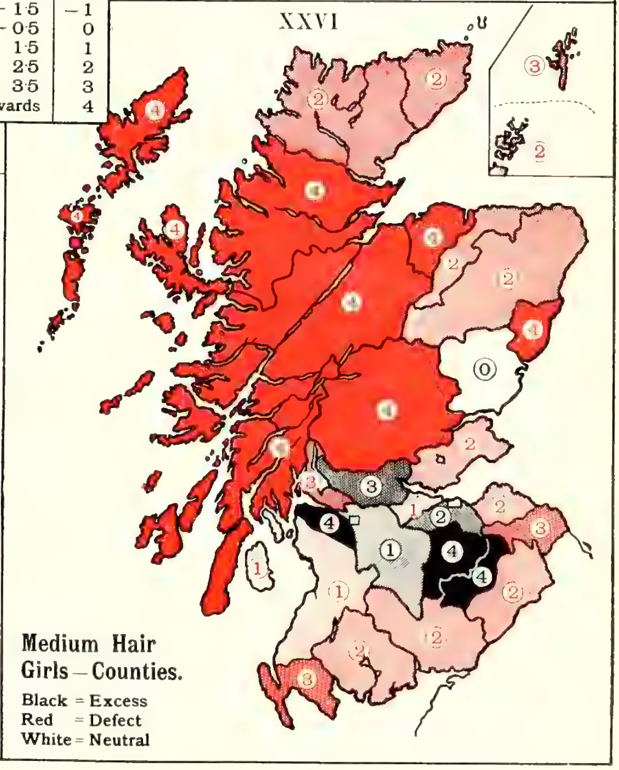
SCALE

R. L. D.	Class
− 3·5 upwards	− 4
− 2·5 to − 3·5	− 3
− 1·5 to − 2·5	− 2
− 0·5 to − 1·5	− 1
+ 0·5 to − 0·5	0
+ 0·5 to 1·5	1
1·5 to 2·5	2
2·5 to 3·5	3
3·5 upwards	4



Medium Hair
Boys—Counties.

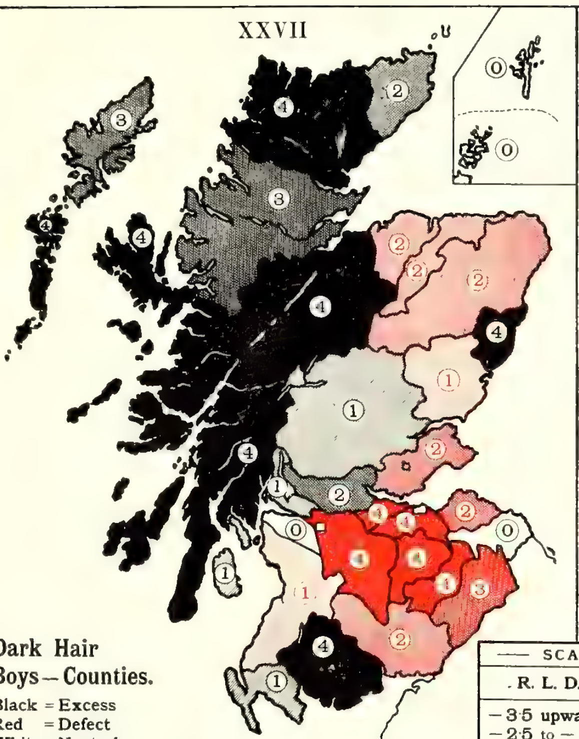
Black = Excess
Red = Defect
White = Neutral



Medium Hair
Girls—Counties.

Black = Excess
Red = Defect
White = Neutral

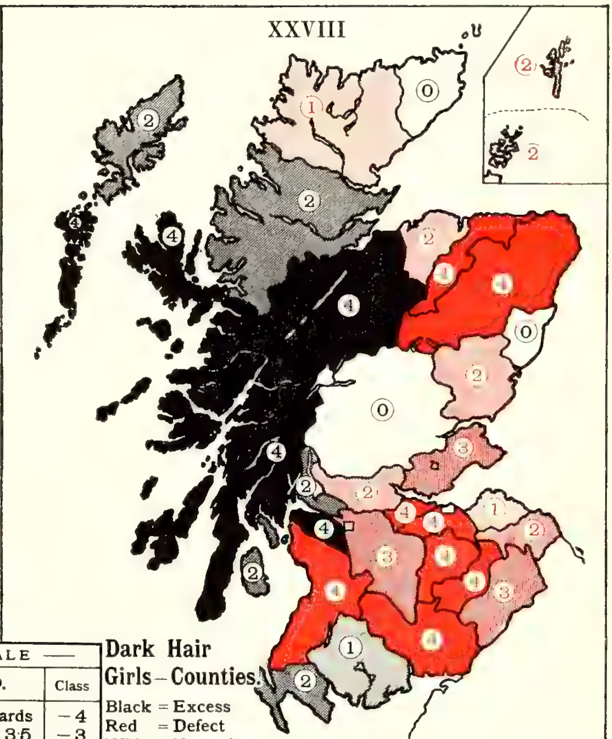
XXVII



Dark Hair Boys — Counties.

Black = Excess
Red = Defect
White = Neutral

XXVIII



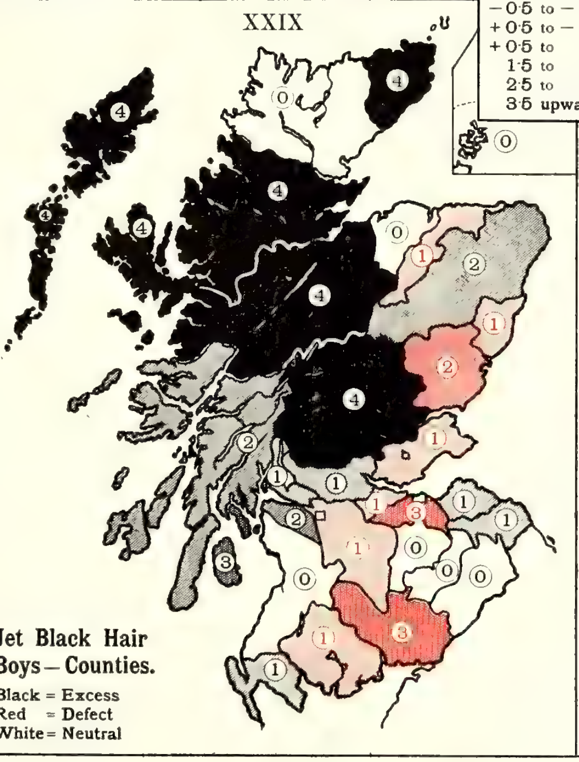
Dark Hair Girls — Counties.

Black = Excess
Red = Defect
White = Neutral

SCALE

R. L. D.	Class
−3·5 upwards	−4
−2·5 to −3·5	−3
−1·5 to −2·5	−2
−0·5 to −1·5	−1
+0·5 to −0·5	0
+0·5 to 1·5	1
1·5 to 2·5	2
2·5 to 3·5	3
3·5 upwards	4

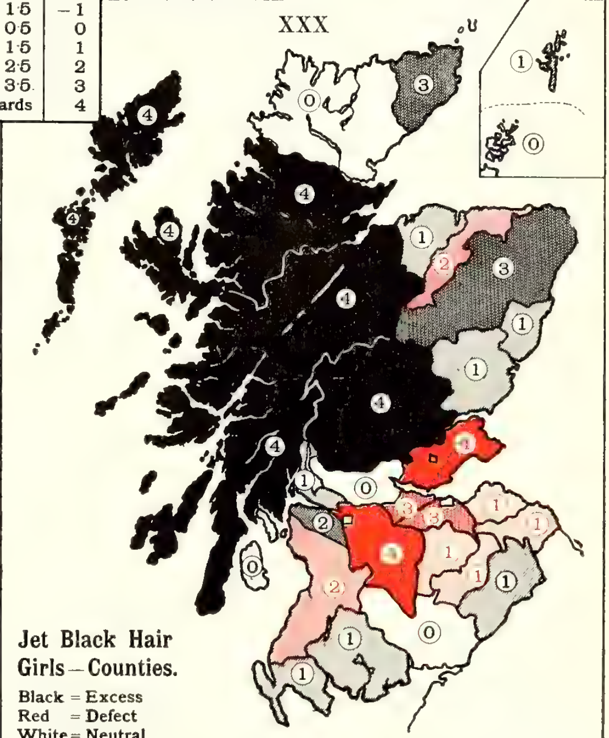
XXIX



Jet Black Hair Boys — Counties.

Black = Excess
Red = Defect
White = Neutral

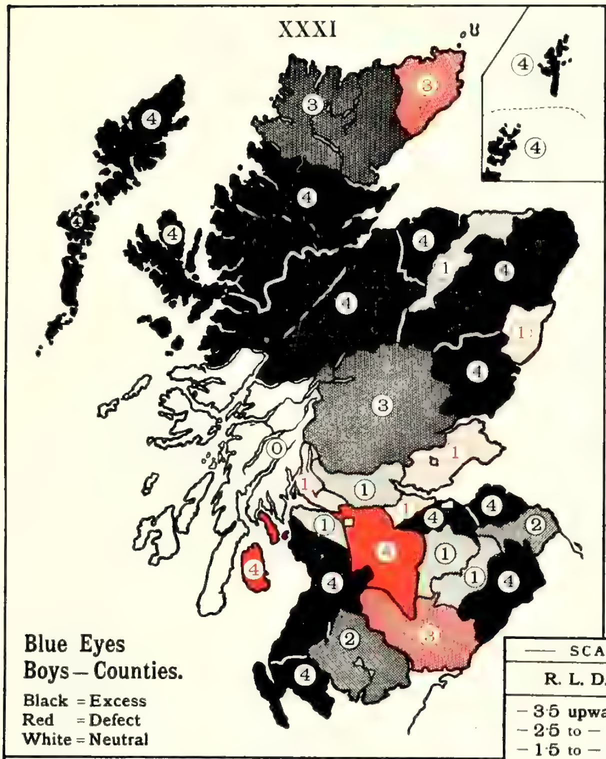
XXX



Jet Black Hair Girls — Counties.

Black = Excess
Red = Defect
White = Neutral

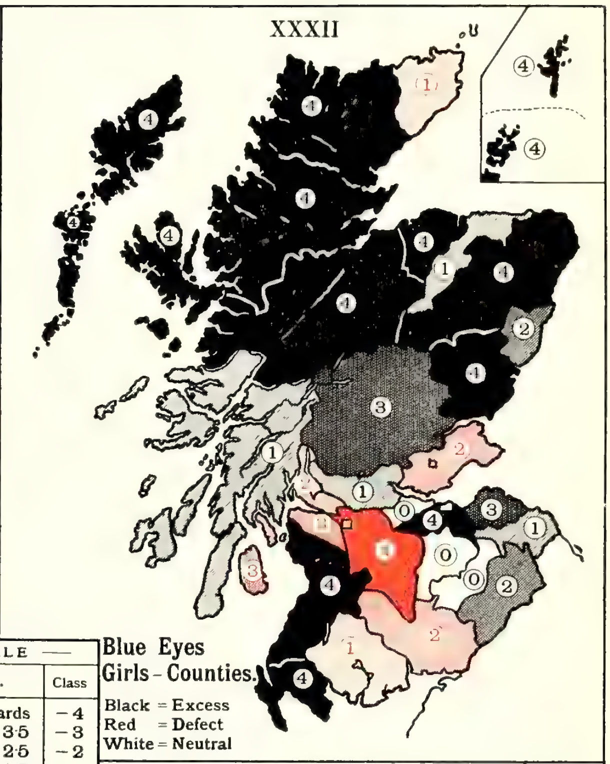
XXXI



Blue Eyes
Boys – Counties.

Black = Excess
Red = Defect
White = Neutral

XXXII

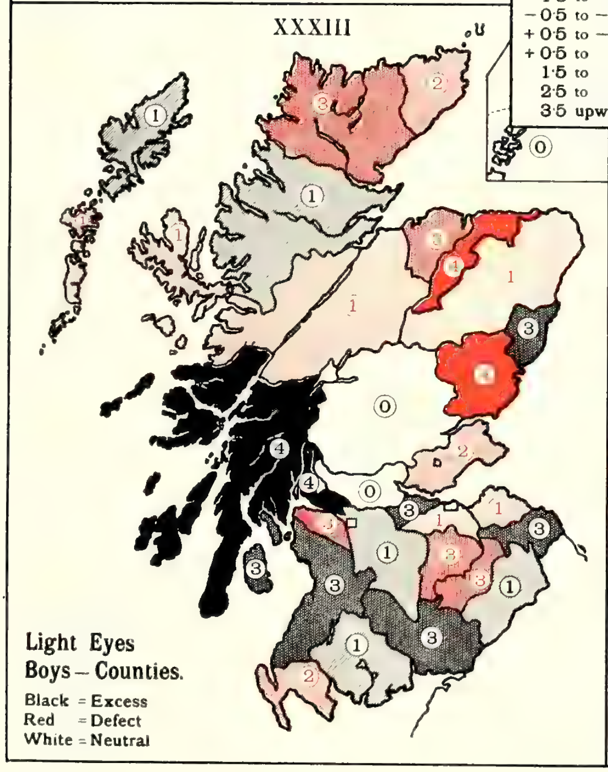


Blue Eyes
Girls - Counties.

Black = Excess
Red = Defect
White = Neutral

SCALE R. L. D.	Class
− 3·5 upwards	− 4
− 2·5 to − 3·5	− 3
− 1·5 to − 2·5	− 2
− 0·5 to − 1·5	− 1
+ 0·5 to − 0·5	0
+ 0·5 to 1·5	1
1·5 to 2·5	2
2·5 to 3·5	3
3·5 upwards	4

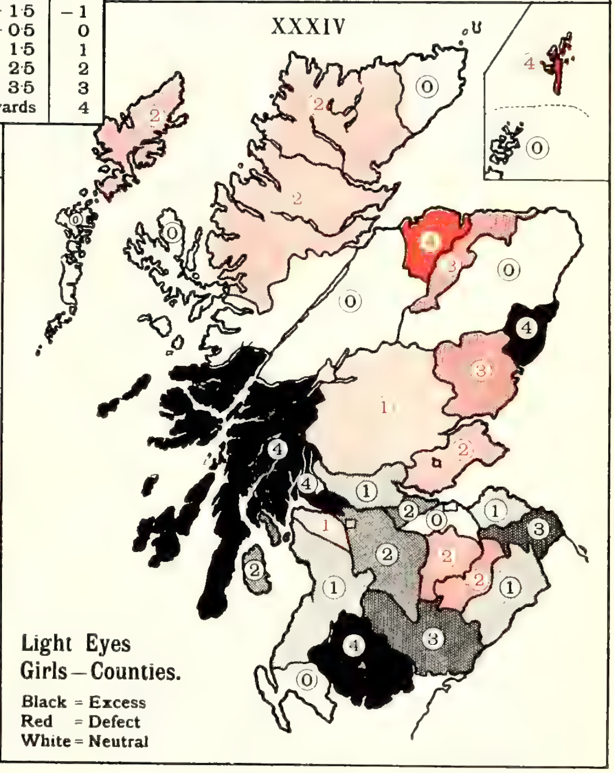
XXXIII



Light Eyes
Boys – Counties.

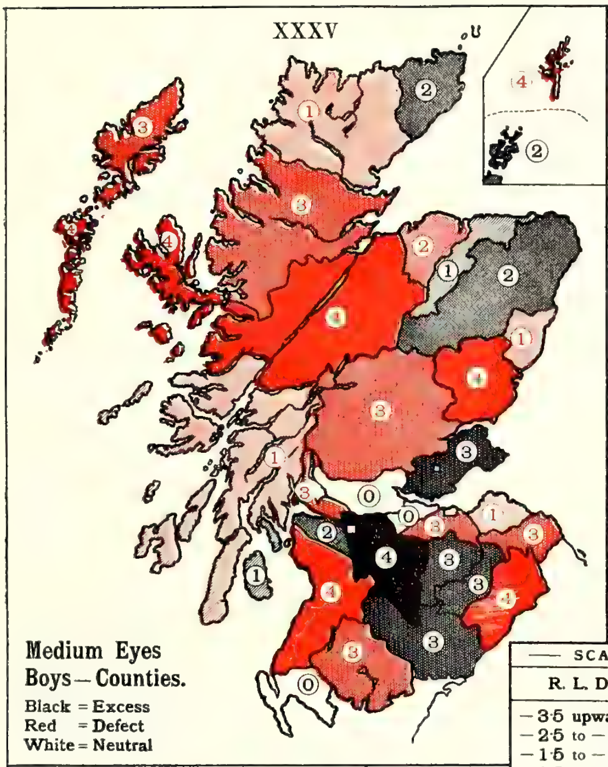
Black = Excess
Red = Defect
White = Neutral

XXXIV



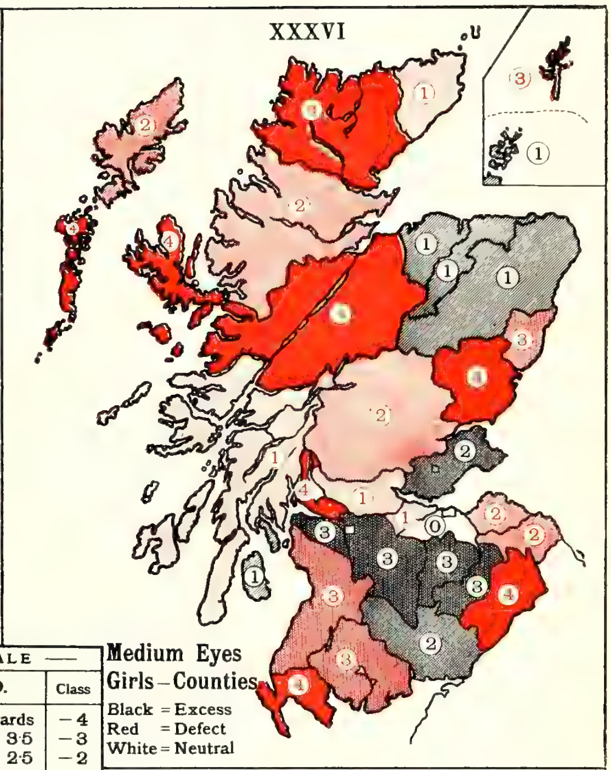
Light Eyes
Girls – Counties.

Black = Excess
Red = Defect
White = Neutral



Medium Eyes
Boys—Counties.

Black = Excess
Red = Defect
White = Neutral

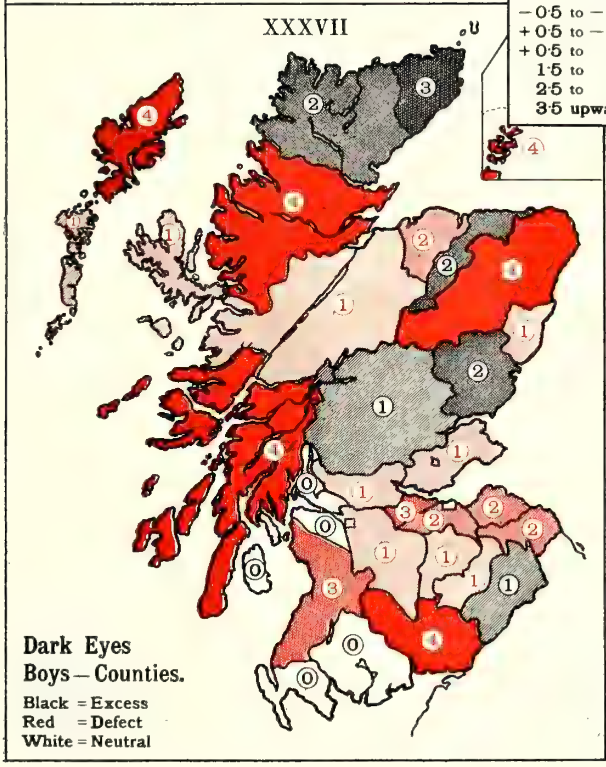


Medium Eyes
Girls—Counties.

Black = Excess
Red = Defect
White = Neutral

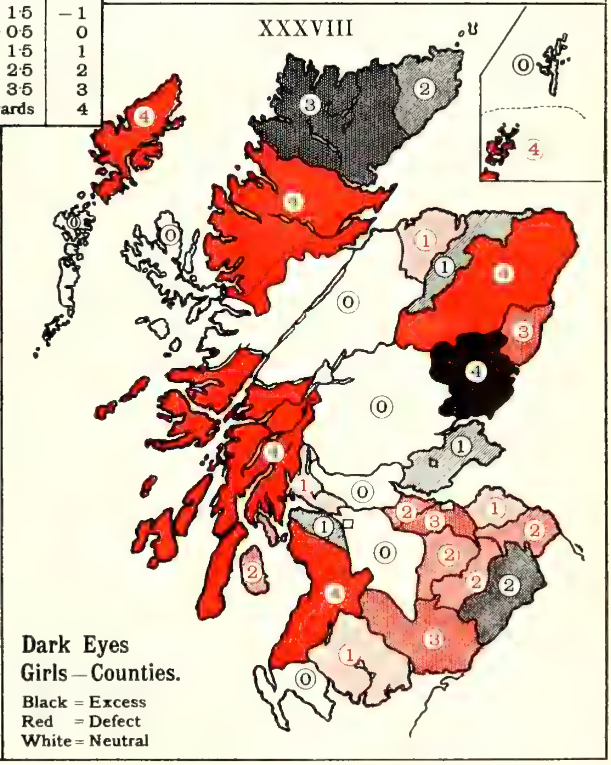
SCALE

R. L. D.	Class
− 3·5 upwards	− 4
− 2·5 to − 3·5	− 3
− 1·5 to − 2·5	− 2
− 0·5 to − 1·5	− 1
+ 0·5 to − 0·5	0
+ 0·5 to 1·5	1
1·5 to 2·5	2
2·5 to 3·5	3
3·5 upwards	4



Dark Eyes
Boys—Counties.

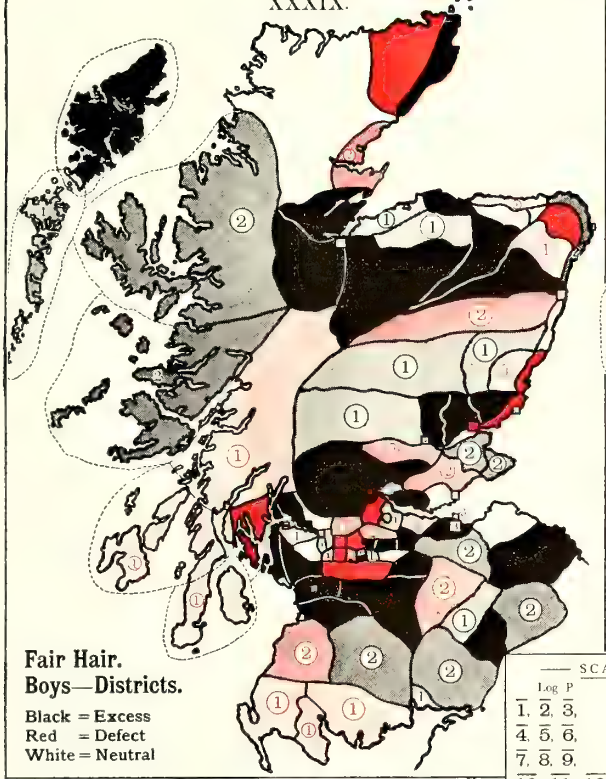
Black = Excess
Red = Defect
White = Neutral



Dark Eyes
Girls—Counties.

Black = Excess
Red = Defect
White = Neutral

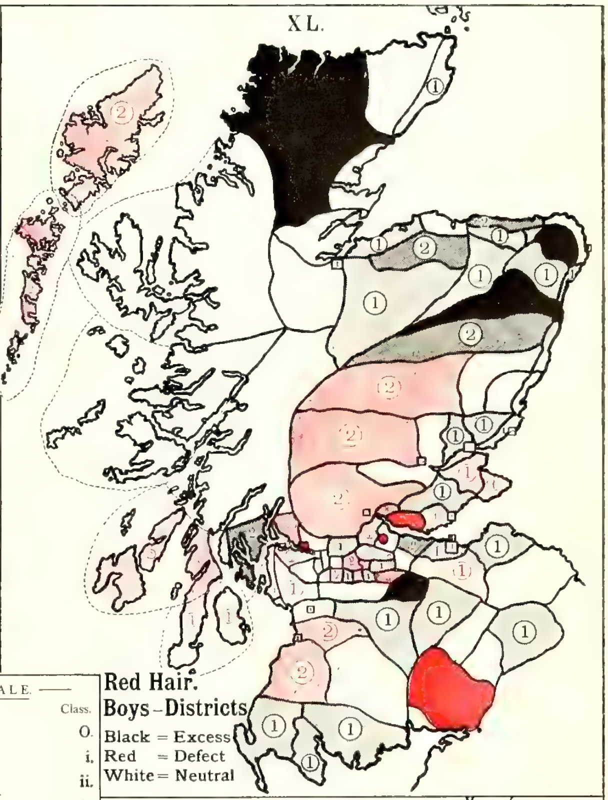
XXXIX.



Fair Hair.
Boys—Districts.

Black = Excess
Red = Defect
White = Neutral

XL.



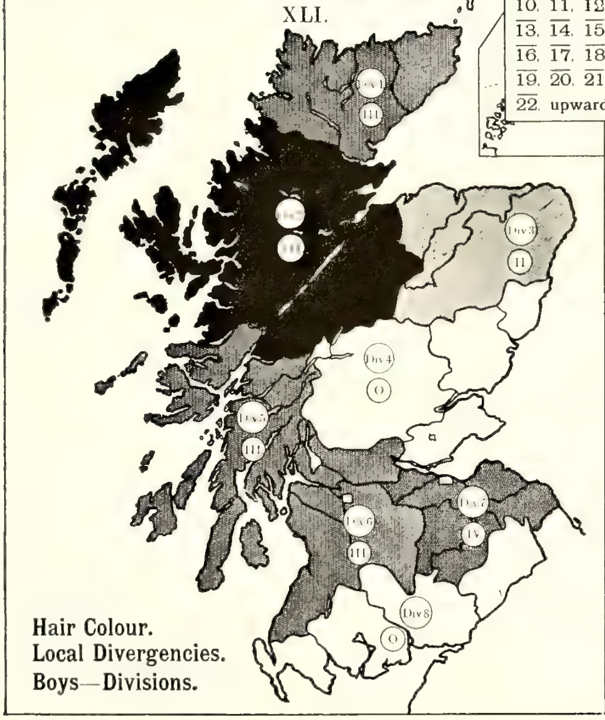
Red Hair.
Boys–Districts.

Black = Excess
Red = Defect
White = Neutral

SCALE.

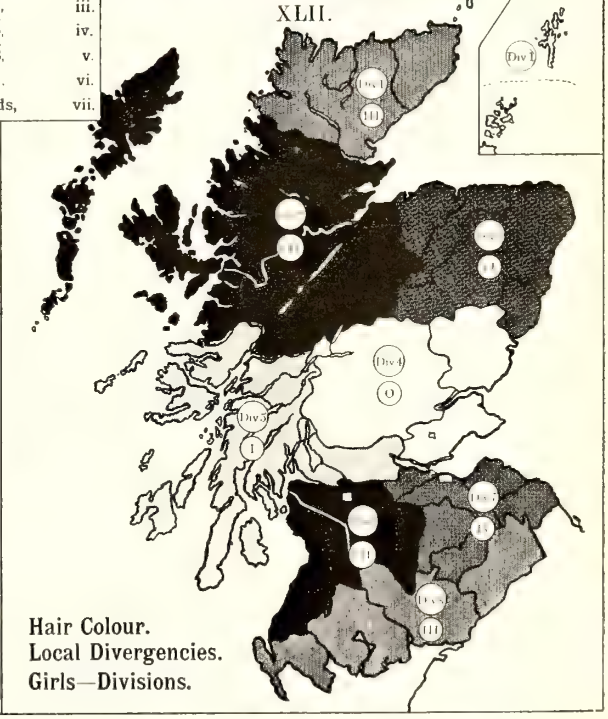
Log P			Class.
$\overline{1}$,	$\overline{2}$,	$\overline{3}$,	O.
$\overline{4}$,	$\overline{5}$,	$\overline{6}$,	i.
$\overline{7}$,	$\overline{8}$,	$\overline{9}$,	ii.
$\overline{10}$,	$\overline{11}$,	$\overline{12}$,	iii.
$\overline{13}$,	$\overline{14}$,	$\overline{15}$,	iv.
$\overline{16}$,	$\overline{17}$,	$\overline{18}$,	v.
$\overline{19}$,	$\overline{20}$,	$\overline{21}$,	vi.
$\overline{22}$,	upwards,		vii.

XLI.

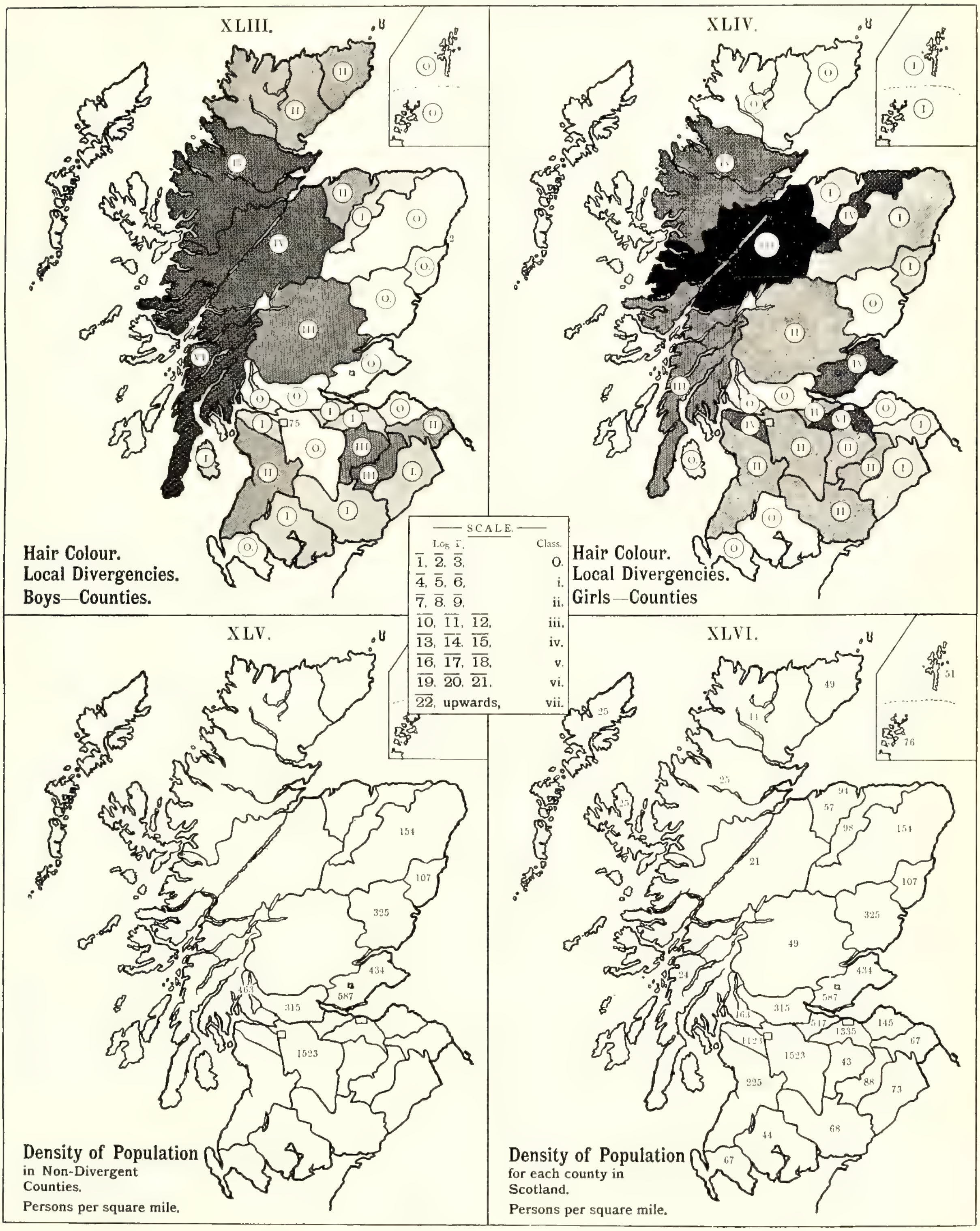

Div 1
III
III
Div 3
II
Div 4
O
Div 5
III
Div 6
III
Div 7
IV
Div 8
O

Hair Colour.
Local Divergencies.
Boys—Divisions.

XLII.


Div 1
Div 1
III
III
Div 4
O
Div 5
I
III

Hair Colour.
Local Divergencies.
Girls—Divisions.


XLIII.
O
O
II
II
IV
IV
II
I
O
2
O.
O.
III
VII
O
O
O
I
I
I
O
II
75
O.
III
III
I.
II
I
I
I
O.
XLIV.
I
I
O
O
IV
I
IV
VIII
I
1
I
O
II
III
IV
O
II
VI
O
I
IV
O.
II
II
II
II
I
O
II
O
XLV.
154
107
325
434
463
587
315
1523
XLVI.
49
51
76
25
11
25
25
94
57
98
154
21
107
325
49
434
24
587
163
315
517
1335
145
1123
1523
67
43
88
73
225
68
44
67

XLIII. Hair Colour. Local Divergencies. Boys—Counties.

XLIV. Hair Colour. Local Divergencies. Girls—Counties

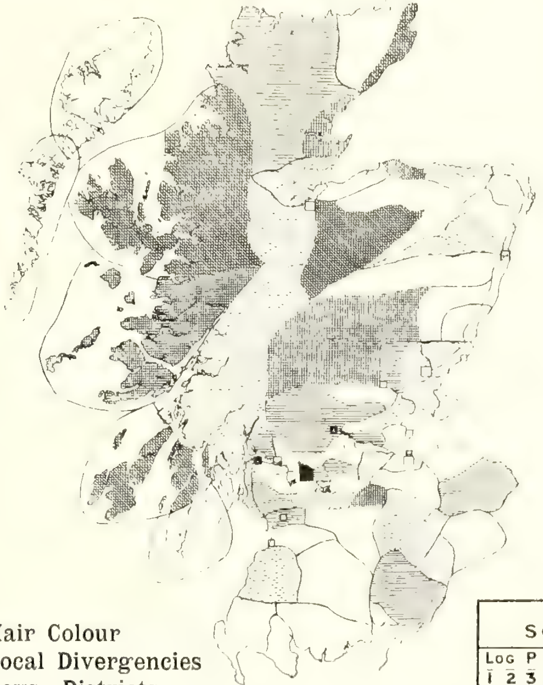
SCALE.

Log r̄.	Class.
$\overline{1}$, $\overline{2}$, $\overline{3}$,	O.
$\overline{4}$, $\overline{5}$, $\overline{6}$,	i.
$\overline{7}$, $\overline{8}$, $\overline{9}$,	ii.
$\overline{10}$, $\overline{11}$, $\overline{12}$,	iii.
$\overline{13}$, $\overline{14}$, $\overline{15}$,	iv.
$\overline{16}$, $\overline{17}$, $\overline{18}$,	v.
$\overline{19}$, $\overline{20}$, $\overline{21}$,	vi.
$\overline{22}$, upwards,	vii.

XLV. Density of Population in Non-Divergent Counties.
Persons per square mile.

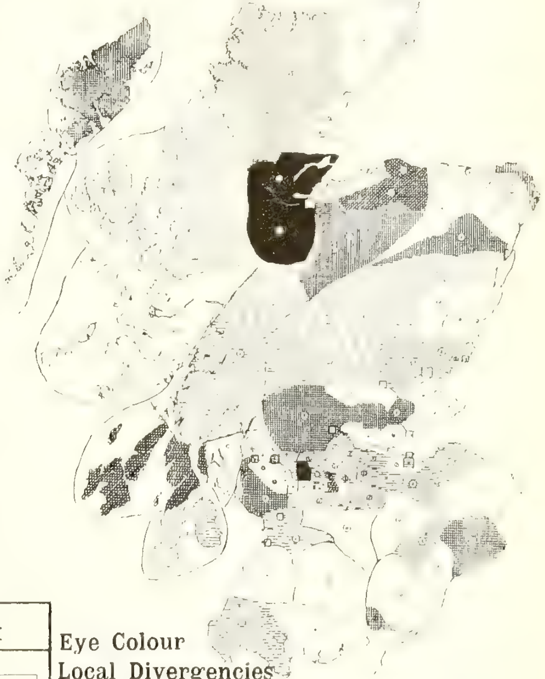
XLVI. Density of Population for each county in Scotland.
Persons per square mile.

XLVII.



Hair Colour
Local Divergencies
Boys—Districts

XLIX.

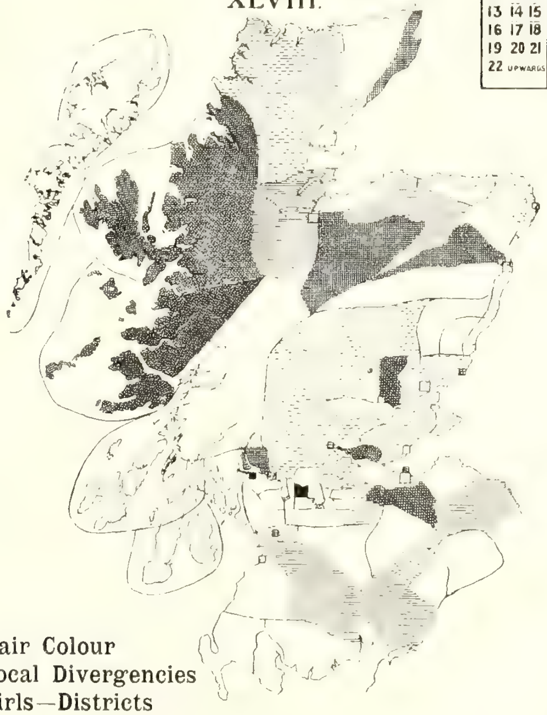


Eye Colour
Local Divergencies
Boys—Districts

SCALE

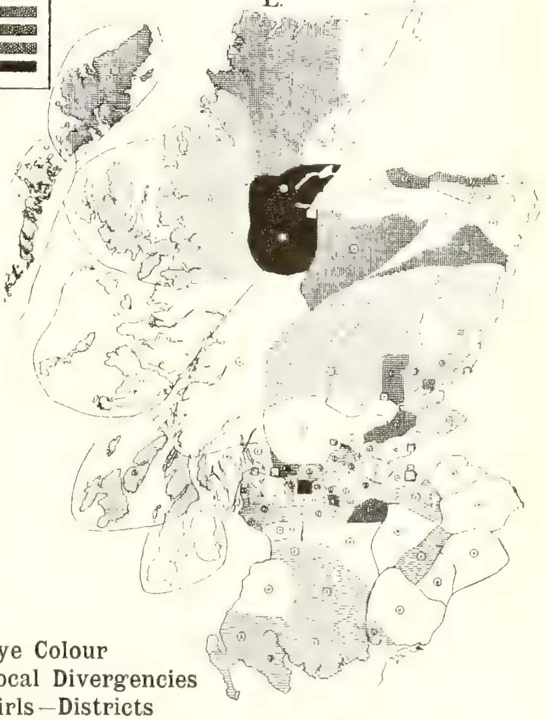
Log	P		Class	
1	2	3	0	☐
4	5	6	I	░
7	8	9	II	░
10	11	12	III	▒
13	14	15	IV	▨
16	17	18	V	▨
19	20	21	VI	▓
22 upwards			VII	■

XLVIII.

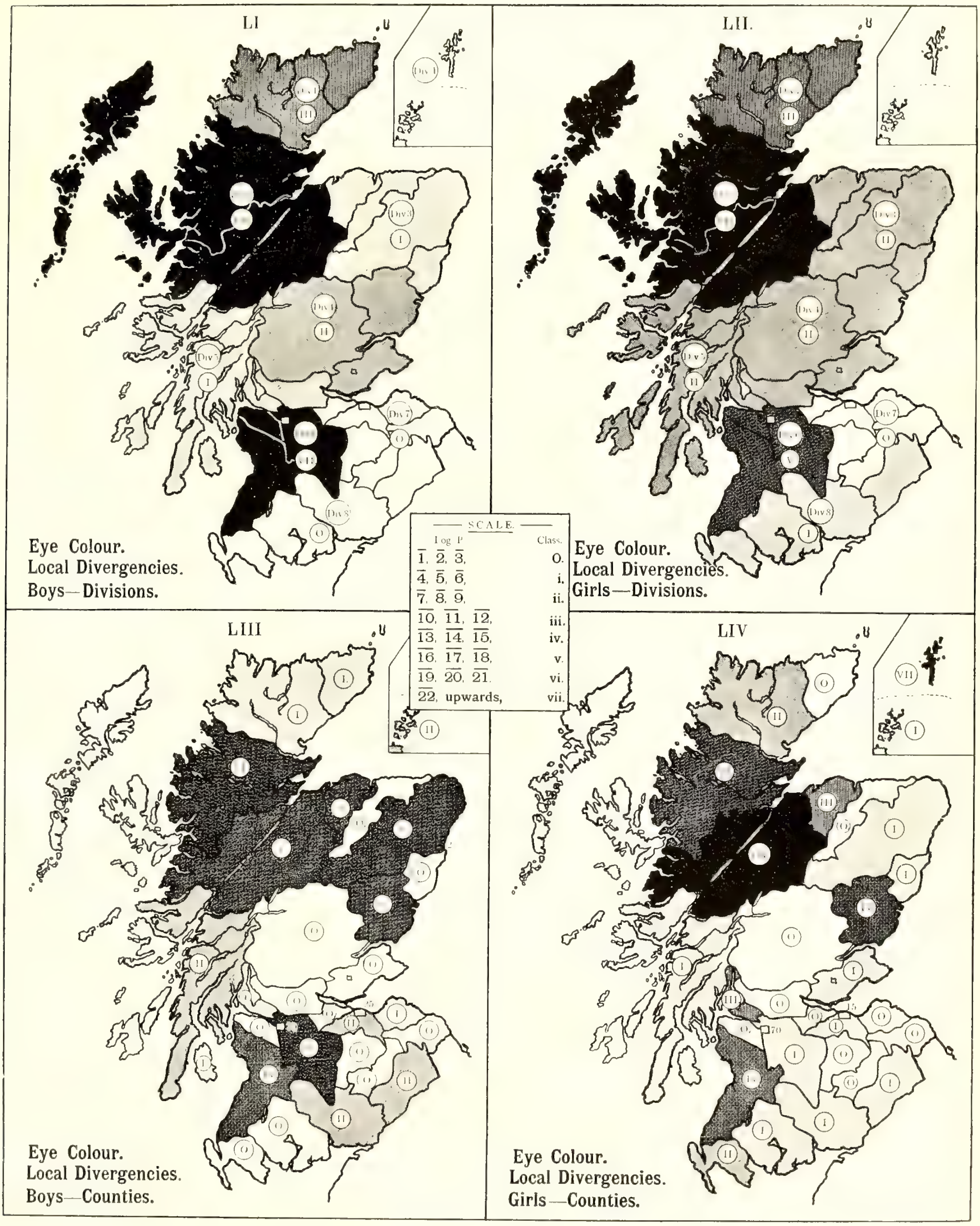


Hair Colour
Local Divergencies
Girls—Districts

L.



Eye Colour
Local Divergencies
Girls—Districts


LI
Div 1
III
Div 3
I
Div 4
II
Div 5
I
Div 7
O
Div 8
O
LII.
Div 3
II
Div 4
II
Div 5
II
Div 7
O
V
Div 8
I
LIII
I.
I
II
O
O
O
O
II
O
I
O
O
II
O
II
II
O
I
LIV
VII
I
O
II
III
O
I
I
O
I
III
O
O
O
I
O
O
70
I
O
O
I
I
I
II
15

LI. Eye Colour. Local Divergencies. Boys—Divisions.

LII. Eye Colour. Local Divergencies. Girls—Divisions.

LIII. Eye Colour. Local Divergencies. Boys—Counties.

LIV. Eye Colour. Local Divergencies. Girls—Counties.

SCALE.

Log P	Class.
$\bar{1}$, $\bar{2}$, $\bar{3}$,	O.
$\bar{4}$, $\bar{5}$, $\bar{6}$,	i.
$\bar{7}$, $\bar{8}$, $\bar{9}$,	ii.
$\overline{10}$, $\overline{11}$, $\overline{12}$,	iii.
$\overline{13}$, $\overline{14}$, $\overline{15}$,	iv.
$\overline{16}$, $\overline{17}$, $\overline{18}$,	v.
$\overline{19}$, $\overline{20}$, $\overline{21}$,	vi.
$\overline{22}$, upwards,	vii.

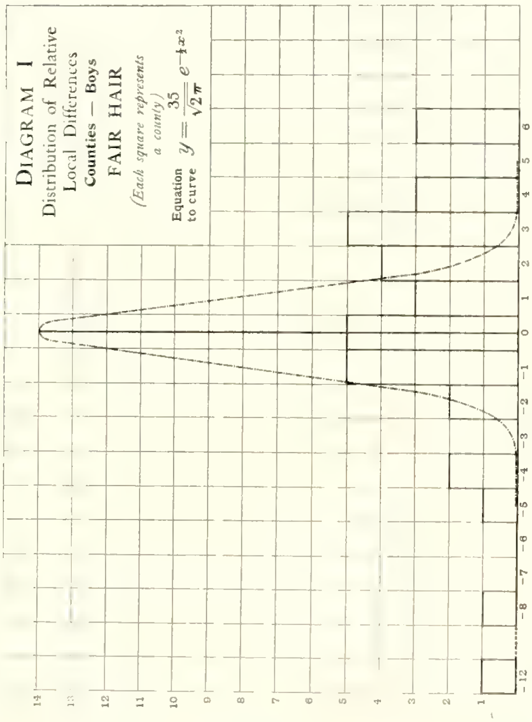


DIAGRAM I
Distribution of Relative
Local Differences
Counties — Boys
FAIR HAIR
(Each square represents a county)
Equation to curve $y = \frac{35}{\sqrt{2\pi}} e^{-\frac{1}{2}x^2}$

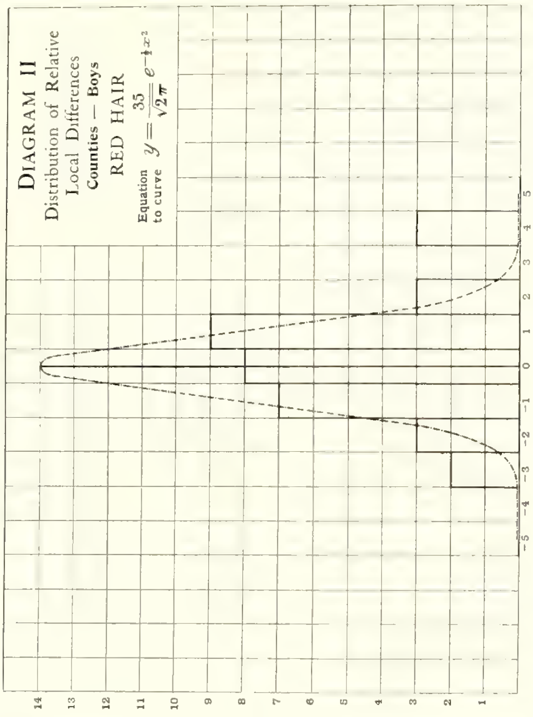


DIAGRAM II
Distribution of Relative
Local Differences
Counties — Boys
RED HAIR
Equation to curve $y = \frac{35}{\sqrt{2\pi}} e^{-\frac{1}{2}x^2}$

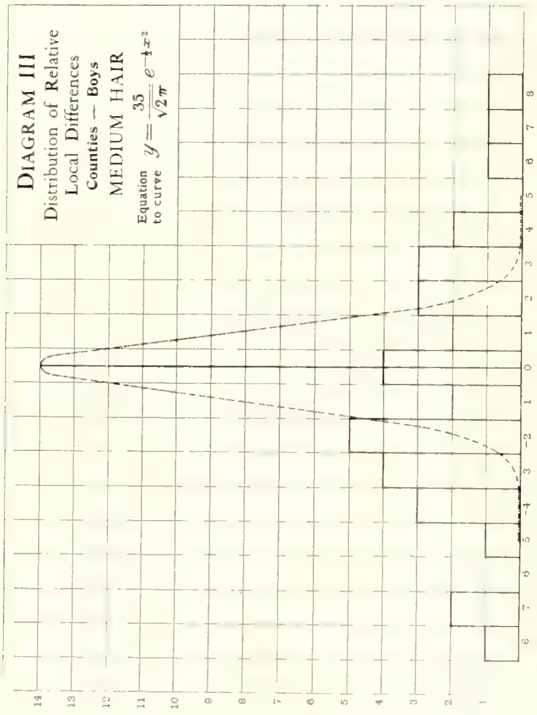


DIAGRAM III
Distribution of Relative
Local Differences
Counties — Boys
MEDIUM HAIR
Equation to curve $y = \frac{35}{\sqrt{2\pi}} e^{-\frac{1}{2}x^2}$

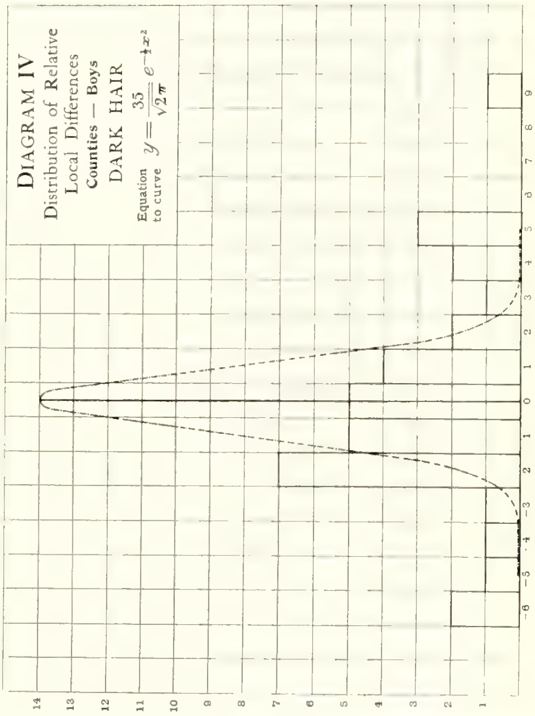


DIAGRAM IV
Distribution of Relative
Local Differences
Counties — Boys
DARK HAIR
Equation to curve $y = \frac{35}{\sqrt{2\pi}} e^{-\frac{1}{2}x^2}$

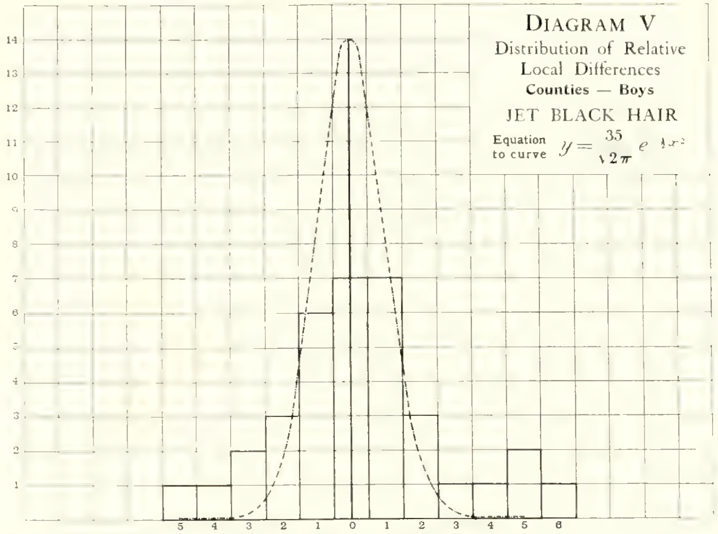


DIAGRAM V
Distribution of Relative
Local Differences
Counties — Boys
JET BLACK HAIR
Equation to curve $y = \frac{35}{\sqrt{2\pi}} e^{-\frac{1}{2}x^2}$

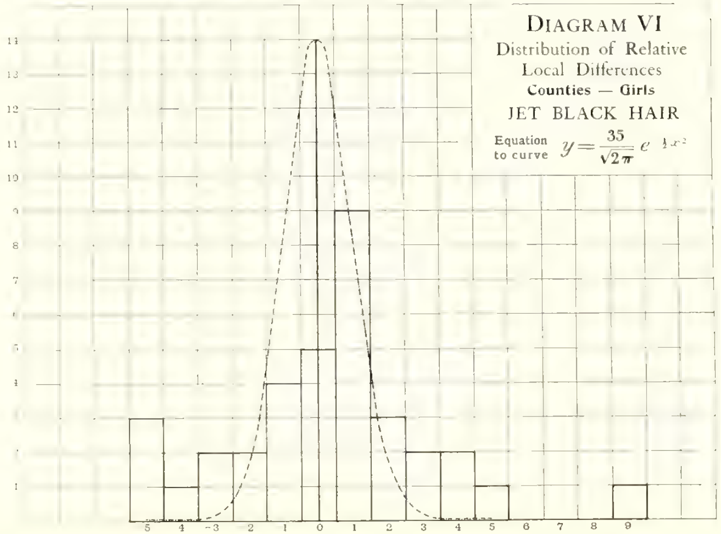


DIAGRAM VI
Distribution of Relative
Local Differences
Counties — Girls
JET BLACK HAIR
Equation to curve $y = \frac{35}{\sqrt{2\pi}} e^{-\frac{1}{2}x^2}$

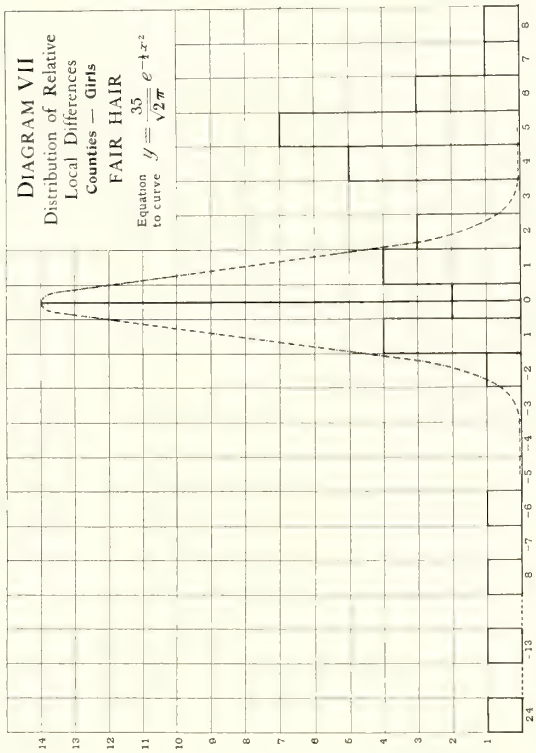


DIAGRAM VII
Distribution of Relative
Local Differences
Counties — Girls
FAIR HAIR
Equation to curve $y = \frac{35}{\sqrt{2\pi}} e^{-\frac{1}{2}x^2}$

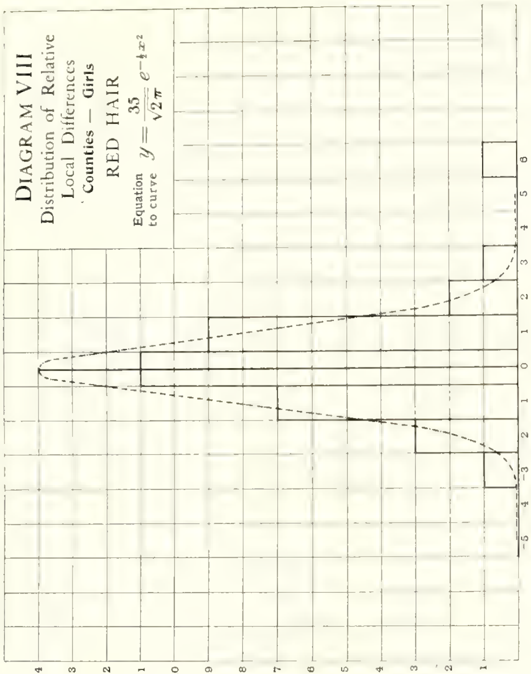


DIAGRAM VIII
Distribution of Relative
Local Differences
Counties — Girls
RED HAIR
Equation to curve $y = \frac{35}{\sqrt{2\pi}} e^{-\frac{1}{2}x^2}$

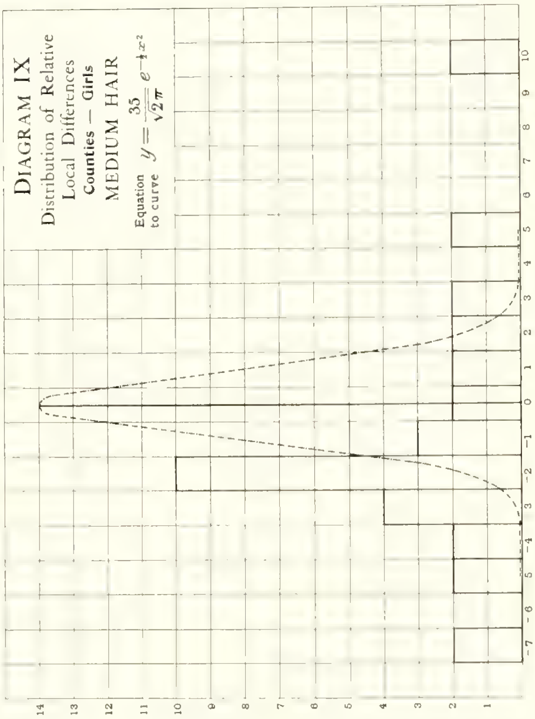


DIAGRAM IX
Distribution of Relative
Local Differences
Counties — Girls
MEDIUM HAIR
Equation to curve $y = \frac{35}{\sqrt{2\pi}} e^{-\frac{1}{2}x^2}$

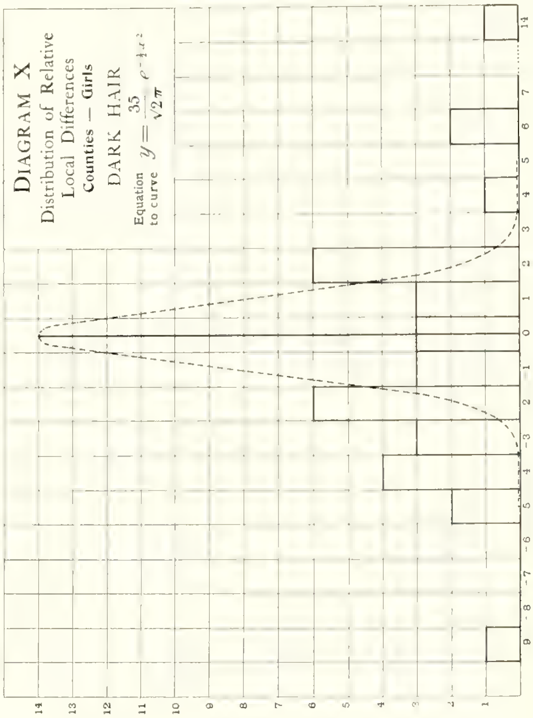


DIAGRAM X
Distribution of Relative
Local Differences
Counties — Girls
DARK HAIR
Equation to curve $y = \frac{35}{\sqrt{2\pi}} e^{-\frac{1}{2}x^2}$

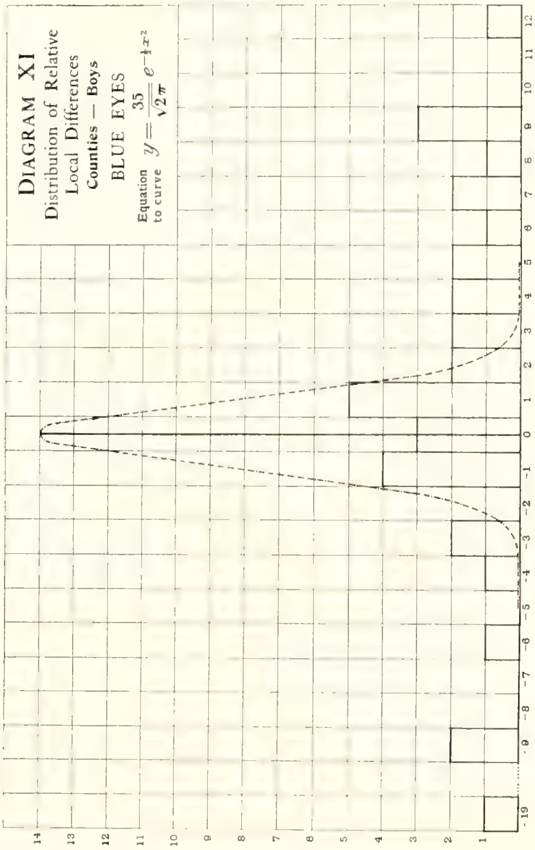


DIAGRAM XI
Distribution of Relative
Local Differences
Counties — Boys
BLUE EYES
Equation to curve $y=\frac{35}{\sqrt{2\pi}}e^{-\frac{1}{2}x^2}$

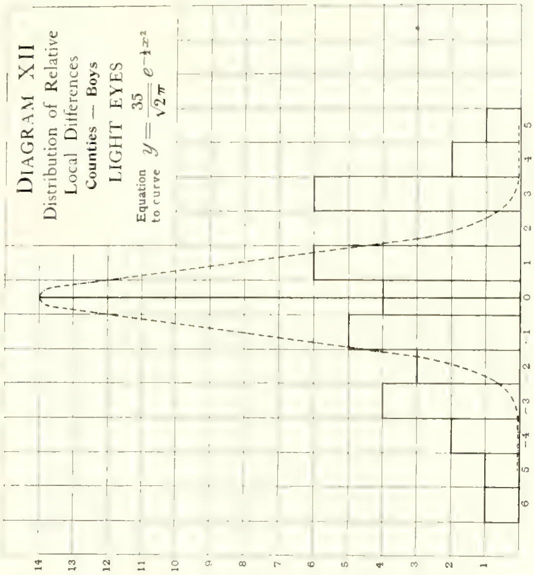


DIAGRAM XII
Distribution of Relative
Local Differences
Counties — Boys
LIGHT EYES
Equation to curve $y=\frac{35}{\sqrt{2\pi}}e^{-\frac{1}{2}x^2}$

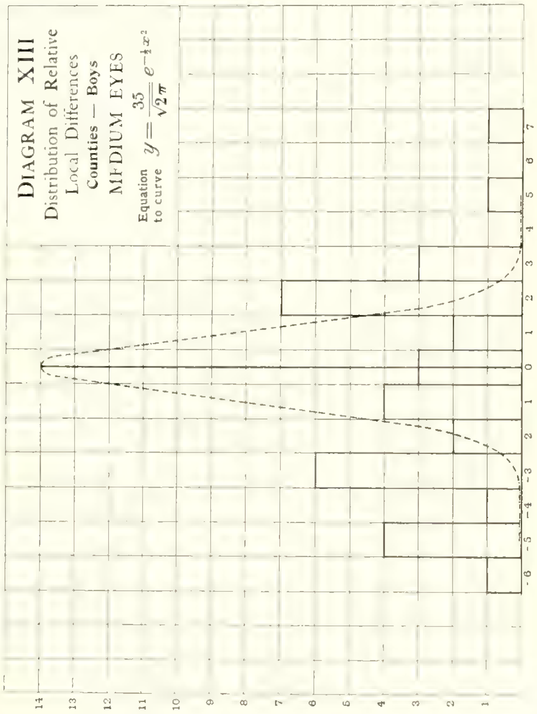


DIAGRAM XIII
Distribution of Relative
Local Differences
Counties — Boys
MEDIUM EYES
Equation to curve $y=\frac{35}{\sqrt{2\pi}}e^{-\frac{1}{2}x^2}$

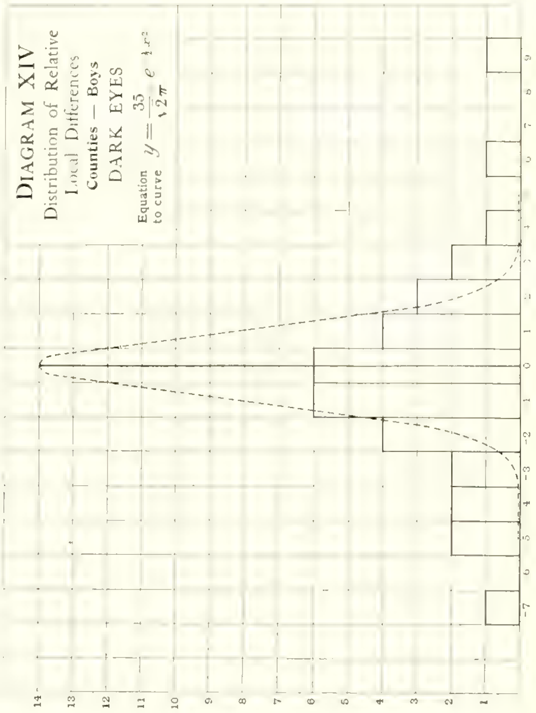


DIAGRAM XIV
Distribution of Relative
Local Differences
Counties — Boys
DARK EYES
Equation to curve $y=\frac{35}{\sqrt{2\pi}}e^{-\frac{1}{2}x^2}$

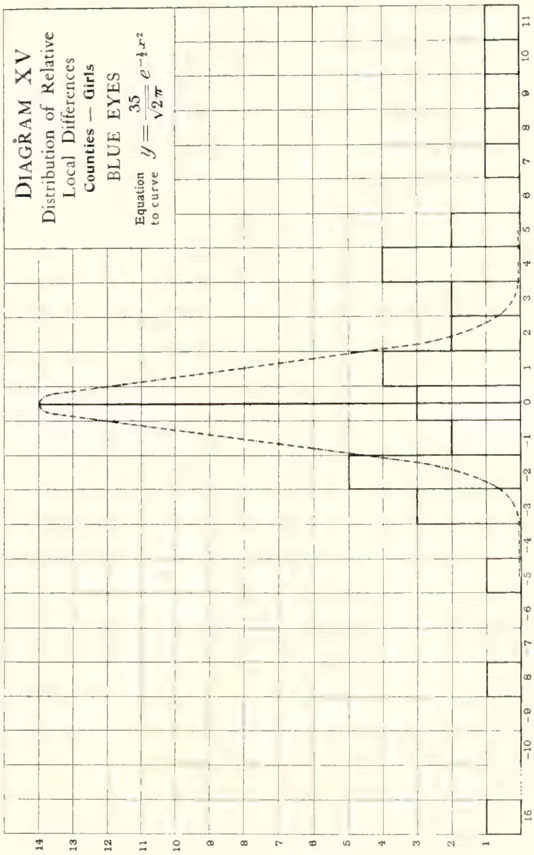


DIAGRAM XV
Distribution of Relative Local Differences
Counties — Girls
BLUE EYES
Equation to curve $y=\frac{35}{\sqrt{2\pi}}e^{-\frac{1}{2}x^2}$

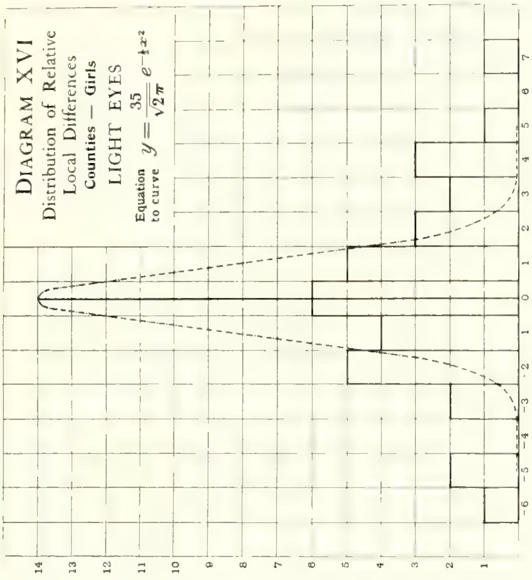


DIAGRAM XVI
Distribution of Relative Local Differences
Counties — Girls
LIGHT EYES
Equation to curve $y=\frac{35}{\sqrt{2\pi}}e^{-\frac{1}{2}x^2}$

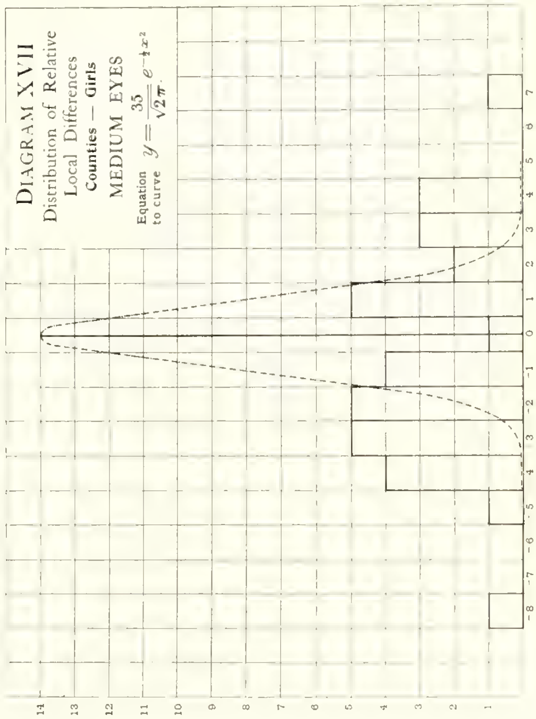


DIAGRAM XVII
Distribution of Relative Local Differences
Counties — Girls
MEDIUM EYES
Equation to curve $y=\frac{35}{\sqrt{2\pi}}e^{-\frac{1}{2}x^2}$.

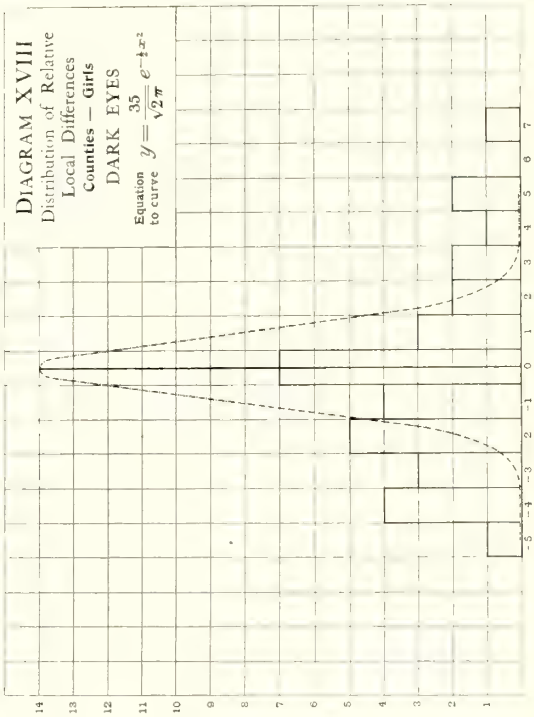
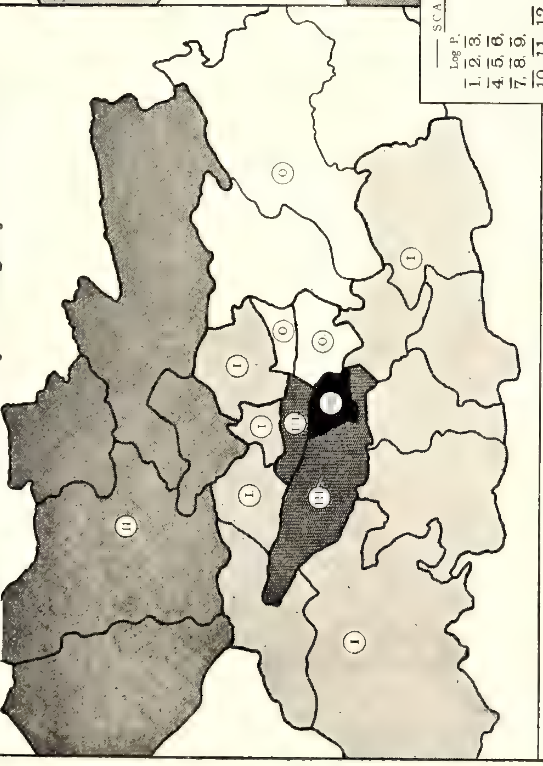
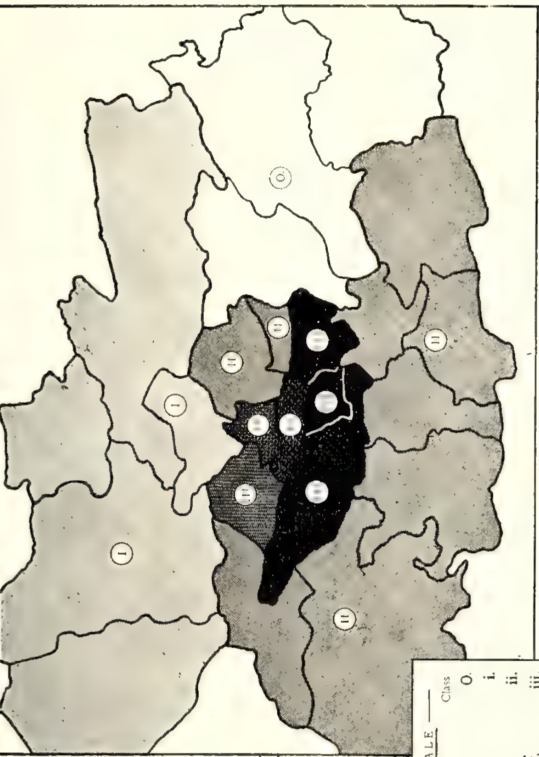


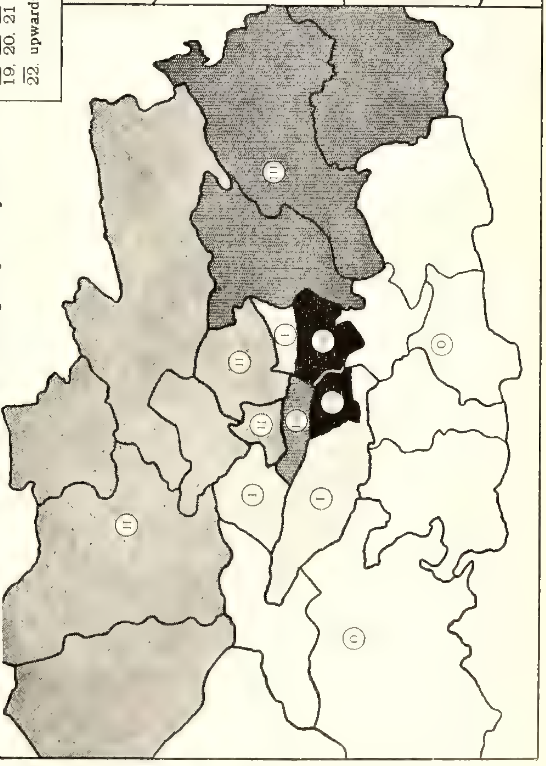
DIAGRAM XVIII
Distribution of Relative Local Differences
Counties — Girls
DARK EYES
Equation to curve $y=\frac{35}{\sqrt{2\pi}}e^{-\frac{1}{2}x^2}$



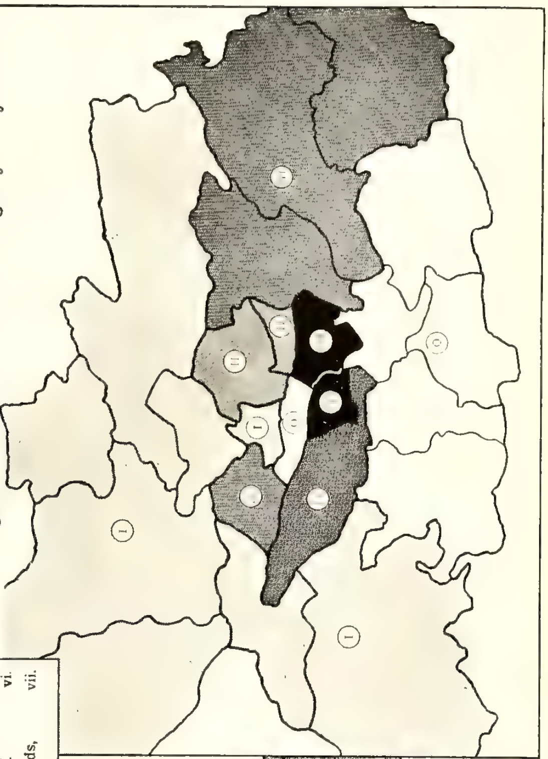
MAP LV.
Greater Glasgow and Environs. Boys—Divergency in Hair Colour.



MAP LVI.
Greater Glasgow and Environs. Girls—Divergency in Hair Colour.



MAP LVII.
Greater Glasgow and Environs. Boys—Divergency in Eye Colour.

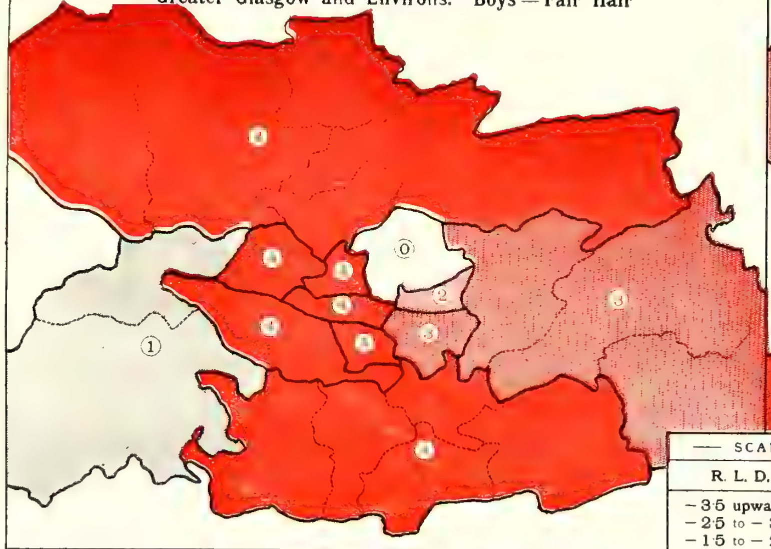


MAP LVIII.
Greater Glasgow and Environs. Girls—Divergency in Eye Colour.

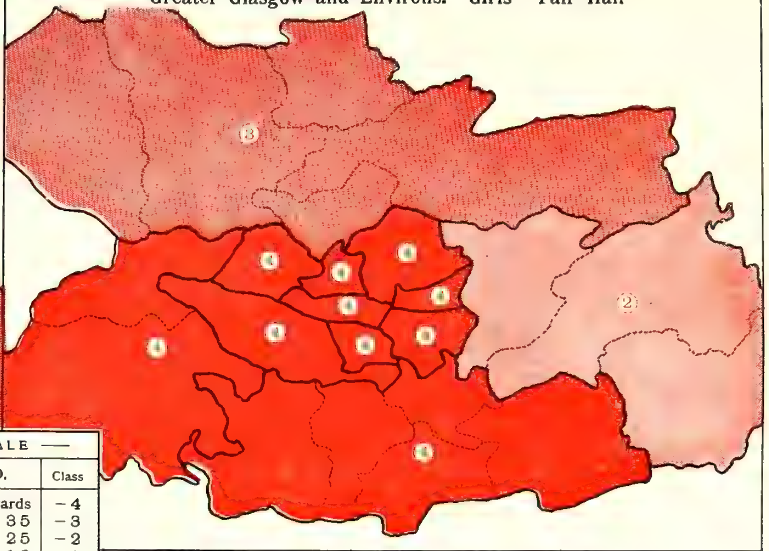
SCALE

Log P.	Class
$\bar{1}, \bar{2}, \bar{3},$	O.
$\bar{4}, \bar{5}, \bar{6},$	i.
$\bar{7}, \bar{8}, \bar{9},$	ii.
$\overline{10}, \overline{11}, \overline{12},$	iii.
$\overline{13}, \overline{14}, \overline{15},$	iv.
$\overline{16}, \overline{17}, \overline{18},$	v
$\overline{19}, \overline{20}, \overline{21}$	vi.
$\overline{22}$, upwards,	vii.

Map LIX.
Greater Glasgow and Environs. Boys — Fair Hair



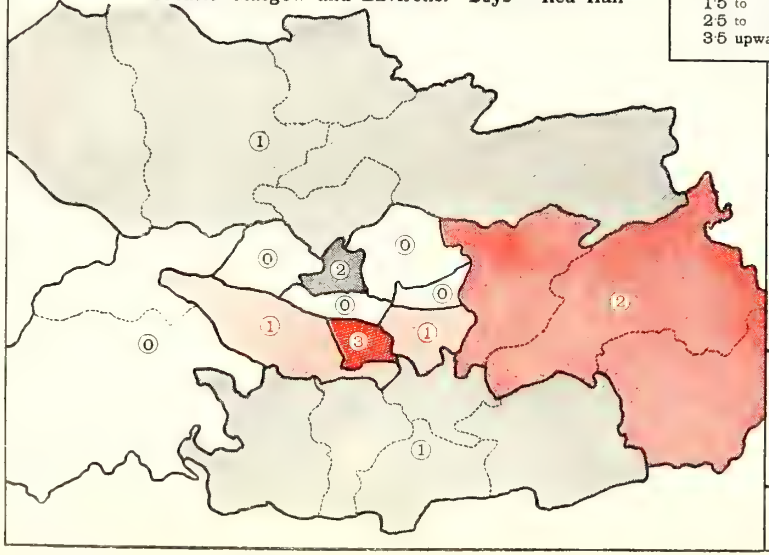
Map LX.
Greater Glasgow and Environs. Girls — Fair Hair



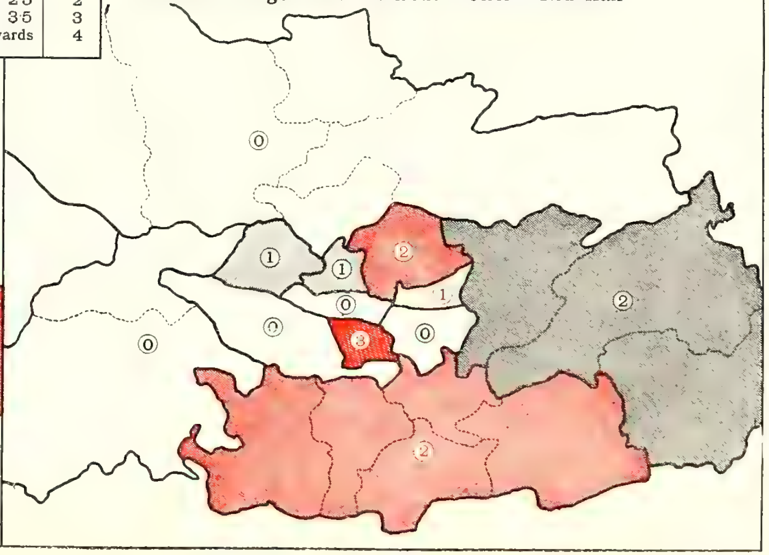
— SCALE —

R. L. D.	Class
− 3·5 upwards	− 4
− 2·5 to − 3·5	− 3
− 1·5 to − 2·5	− 2
− 0·5 to − 1·5	− 1
+ 0·5 to − 0·5	0
+ 0·5 to 1·5	1
1·5 to 2·5	2
2·5 to 3·5	3
3·5 upwards	4

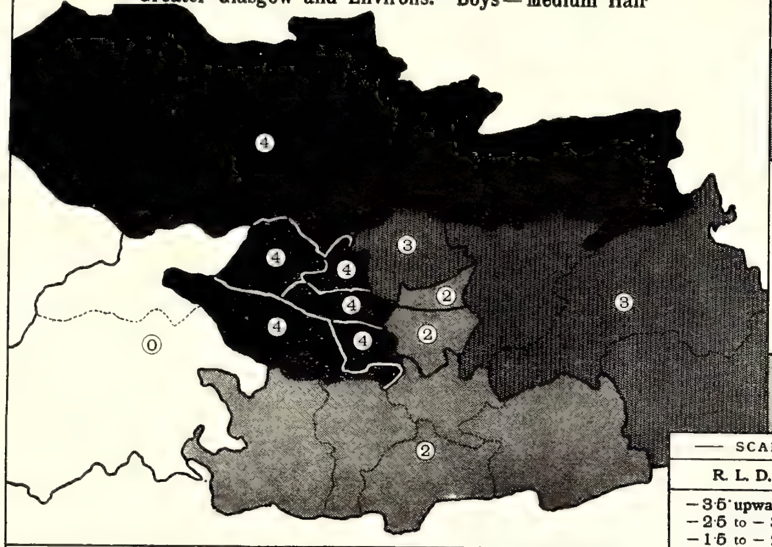
Map LXI.
Greater Glasgow and Environs. Boys — Red Hair



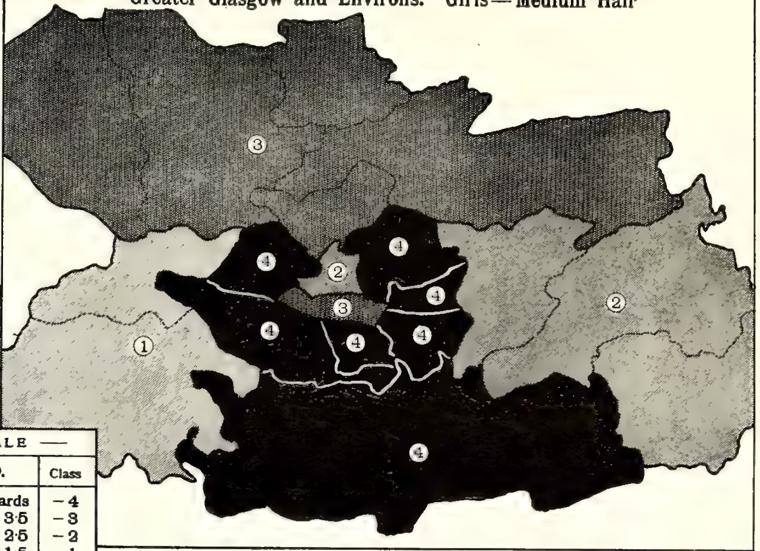
Map LXII.
Greater Glasgow and Environs. Girls — Red Hair



Map LXIII.
Greater Glasgow and Environs. Boys—Medium Hair


4
4
4
3
4
2
3
4
2
4
0
2

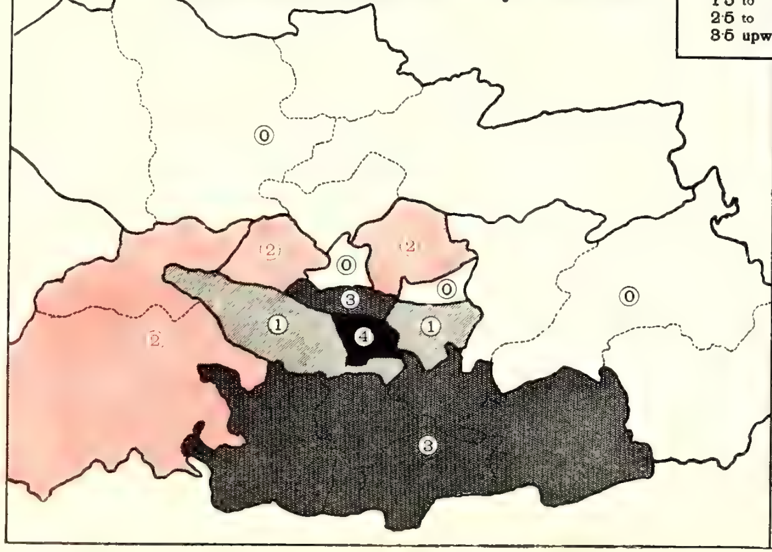
Map LXIV.
Greater Glasgow and Environs. Girls—Medium Hair


3
4
4
2
4
3
2
1
4
4
4
4

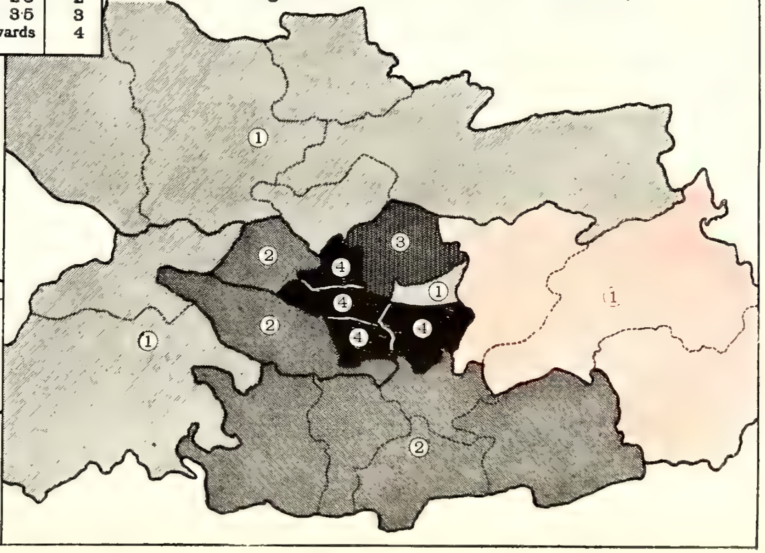
— SCALE —

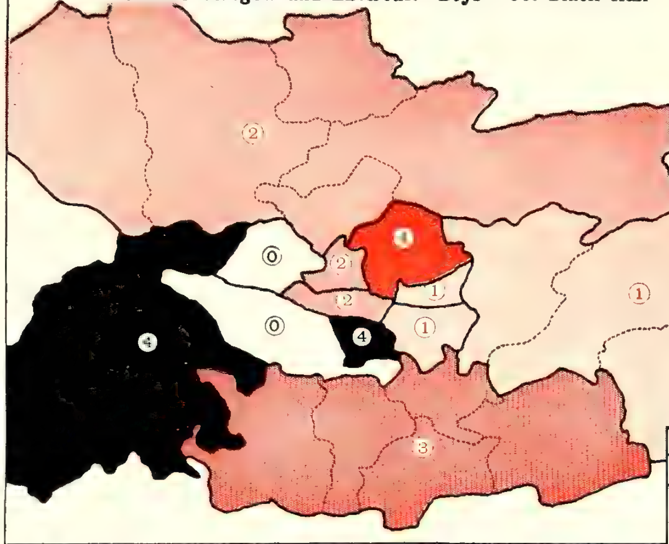
R. L. D.	Class
− 3·5 upwards	− 4
− 2·5 to − 3·5	− 3
− 1·5 to − 2·5	− 2
− 0·5 to − 1·5	− 1
+ 0·5 to − 0·5	0
+ 0·5 to 1·5	1
1·5 to 2·5	2
2·5 to 3·5	3
3·5 upwards	4

Map LXV.
Greater Glasgow and Environs. Boys—Dark Hair

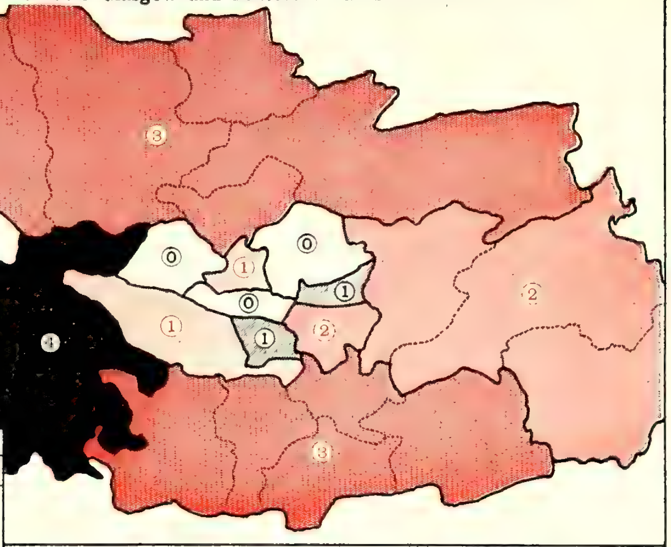

0
2
2
0
0
0
3
2
1
1
4
3

Map LXVI.
Greater Glasgow and Environs. Girls—Dark Hair


1
3
2
4
1
1
4
2
4
4
1
2



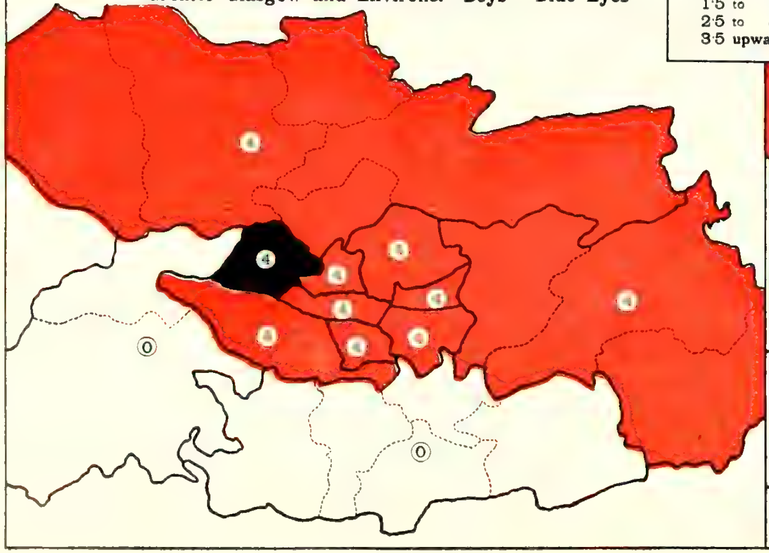
Map LXVII.
Greater Glasgow and Environs. Boys — Jet Black Hair



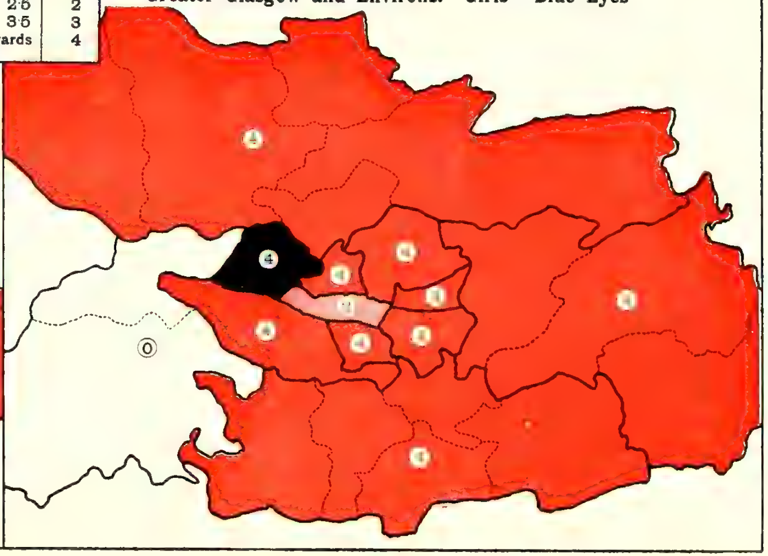
Map LXVIII.
Greater Glasgow and Environs. Girls — Jet Black Hair

SCALE

R. L. D.	Class
− 3·5 upwards	− 4
− 2·5 to − 3·5	− 3
− 1·5 to − 2·5	− 2
− 0·5 to − 1·5	− 1
+ 0·5 to − 0·5	0
+ 0·5 to 1·5	1
1·5 to 2·5	2
2·5 to 3·5	3
3·5 upwards	4

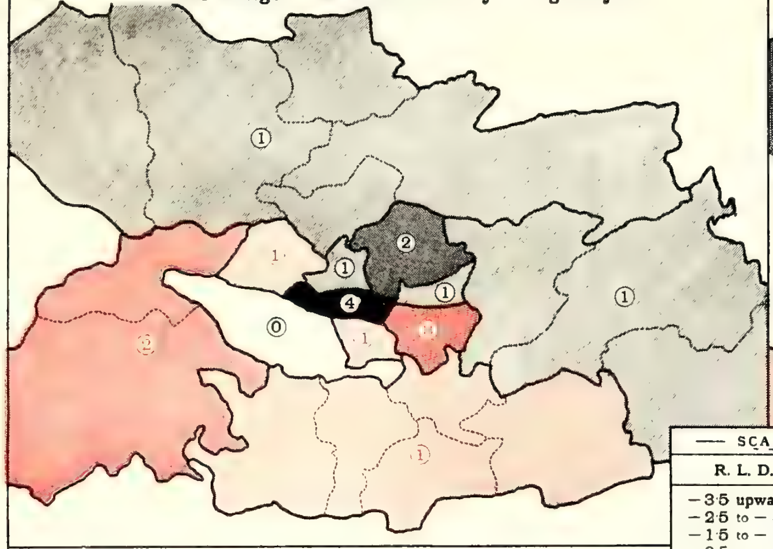


Map LXIX.
Greater Glasgow and Environs. Boys — Blue Eyes

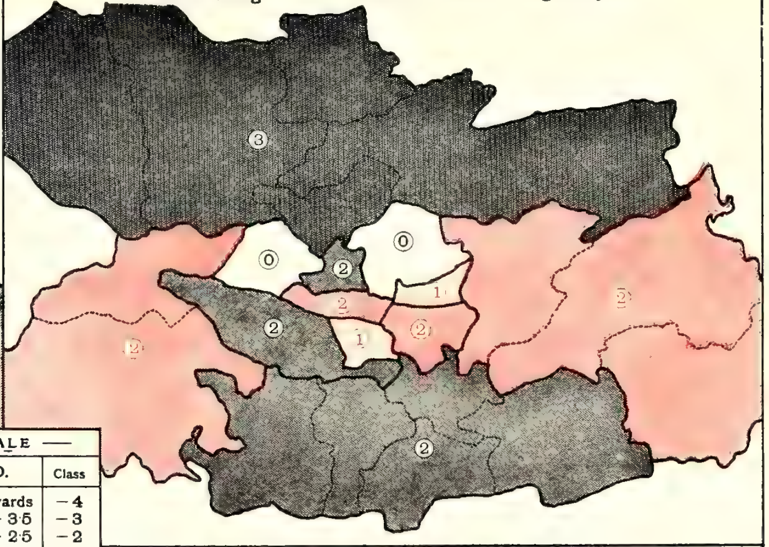


Map LXX.
Greater Glasgow and Environs. Girls — Blue Eyes

Map LXXI.
Greater Glasgow and Environs. Boys — Light Eyes



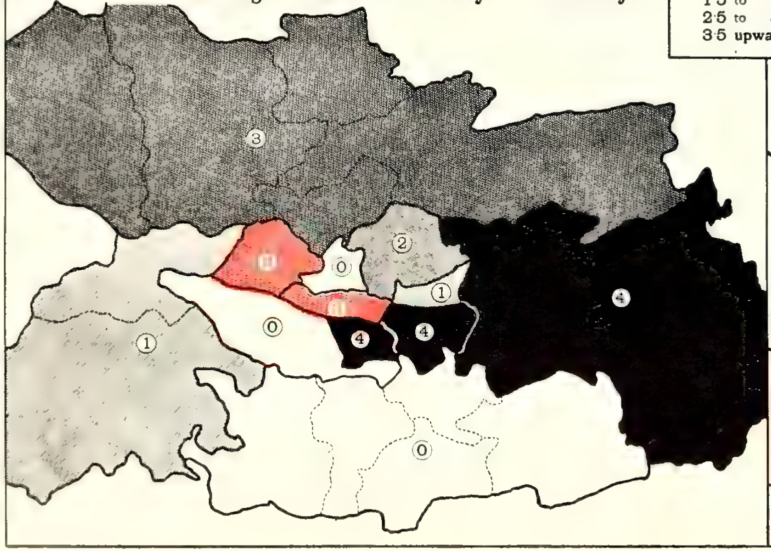
Map LXXII.
Greater Glasgow and Environs. Girls — Light Eyes



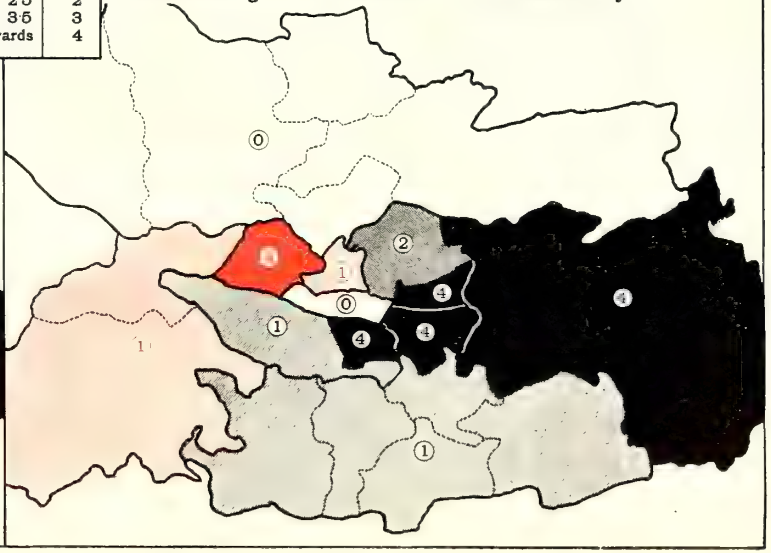
— SCALE —

R. L. D.	Class
− 3·5 upwards	− 4
− 2·5 to − 3·5	− 3
− 1·5 to − 2·5	− 2
− 0·5 to − 1·5	− 1
+ 0·5 to − 0·5	0
+ 0·5 to 1·5	1
1·5 to 2·5	2
2·5 to 3·5	3
3·5 upwards	4

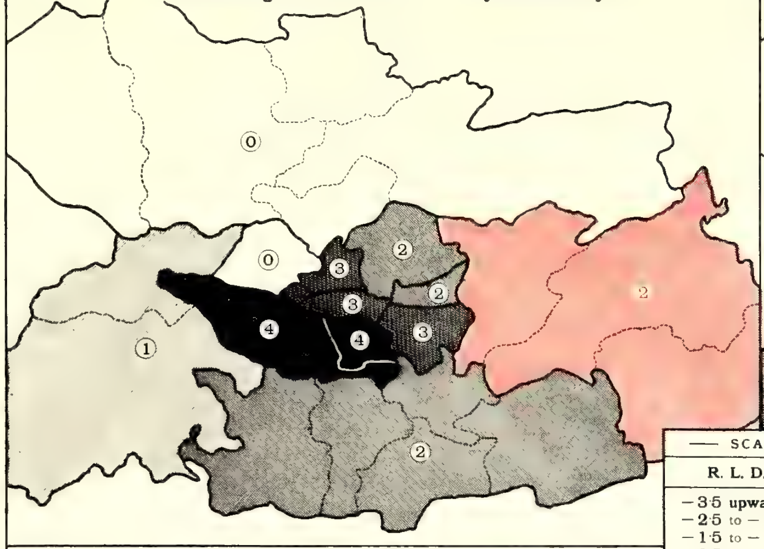
Map LXXIII.
Greater Glasgow and Environs. Boys — Medium Eyes



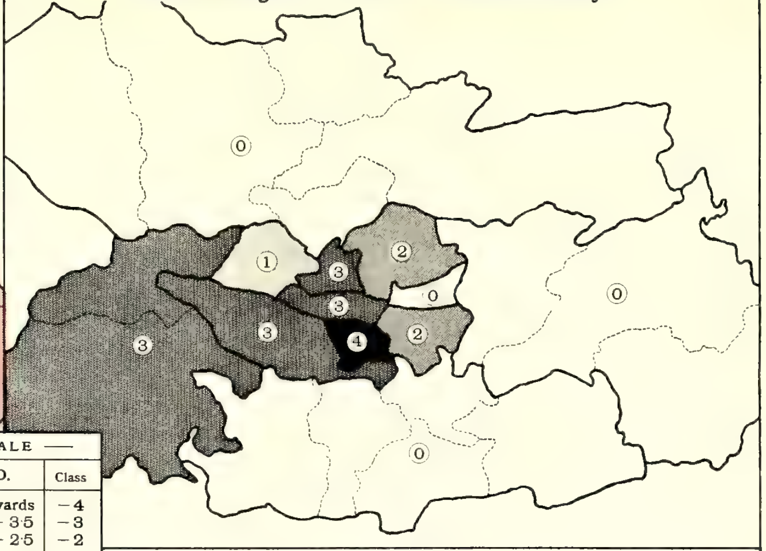
Map LXXIV
Greater Glasgow and Environs. Girls — Medium Eyes



MAP LXXV.
Greater Glasgow and Environs. Boys—Dark Eyes


0
0
1
2
2
2
2
3
3
3
4
4

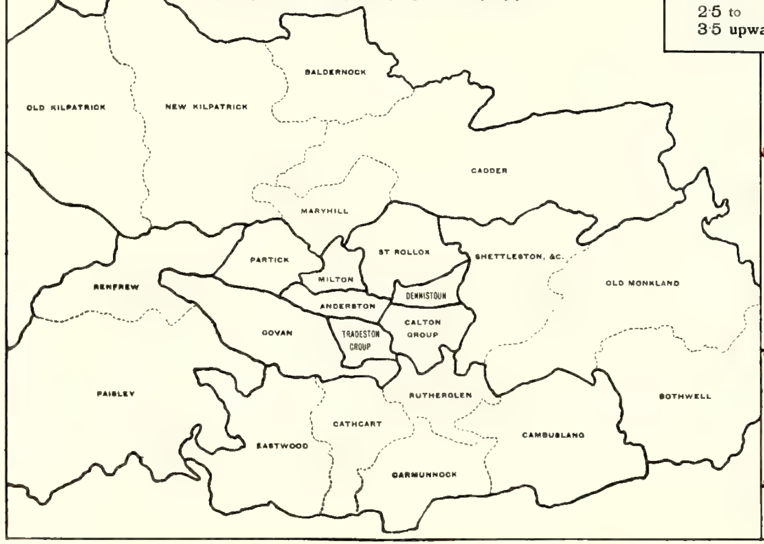
MAP LXXVI.
Greater Glasgow and Environs. Girls—Dark Eyes


0
0
0
0
1
2
2
3
3
3
3
4

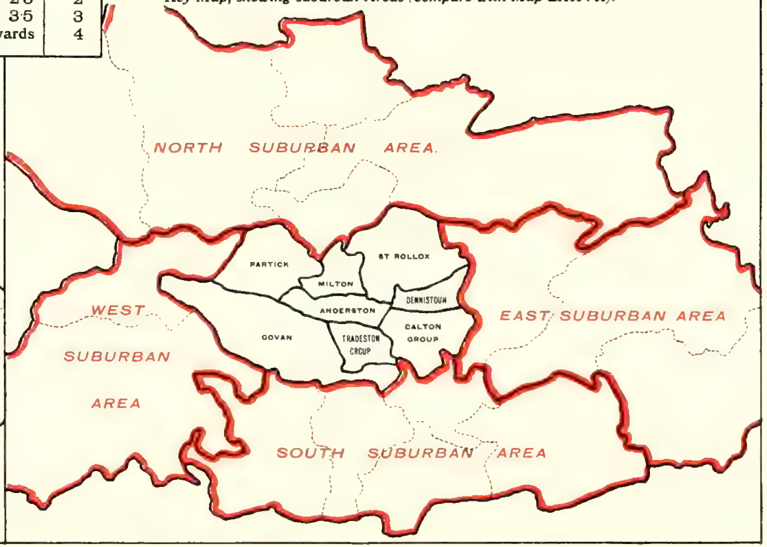
SCALE

R. L. D.	Class
−3·5 upwards	−4
−2·5 to −3·5	−3
−1·5 to −2·5	−2
−0·5 to −1·5	−1
+0·5 to −0·5	0
+0·5 to 1·5	1
1·5 to 2·5	2
2·5 to 3·5	3
3·5 upwards	4

MAP LXXVII.
Greater Glasgow and Environs.
Key Map, showing city grouping and outlying parishes


OLD KILPATRICK
NEW KILPATRICK
BALDERNOCK
CADDER
MARYHILL
PARTICK
ST ROLLOX
SHETTLESTON, &C.
OLD MONKLAND
RENFREW
MILTON
DENNISTOUN
ANDERSTON
GOVAN
TRADESTON GROUP
CALTON GROUP
PAISLEY
RUTHERGLEN
BOTHWELL
CATHCART
EASTWOOD
CAMBUSLANG
CARMUNNOCK

MAP LXXVIII.
Greater Glasgow and Environs.
Key Map, showing suburban Areas (compare with Map LXXVII).


NORTH SUBURBAN AREA.
PARTICK
ST ROLLOX
MILTON
DENNISTOUN
ANDERSTON
GOVAN
TRADESTON GROUP
CALTON GROUP
WEST SUBURBAN AREA
EAST SUBURBAN AREA
SOUTH SUBURBAN AREA

MAPS.

		Pl.
I.	Key Map, Districts and Counties.	I.
II.	„ Divisions, Counties and Chief Towns.	II.

DIVISIONS.

			Pl.
III.	Fair Hair,	Boys.	III.
IV.	„	Girls.	„
V.	Red Hair,	Boys.	„
VI.	„	Girls.	„
VII.	Medium Hair,	Boys.	IV.
VIII.	„	Girls.	„
IX.	Dark Hair,	Boys.	„
X.	„	Girls.	„
XI.	Jet Black Hair,	Boys.	V.
XII.	„	Girls.	„
XIII.	Blue Eyes,	Boys.	„
XIV.	„	Girls.	„
XV.	Light Eyes,	Boys.	VI.
XVI.	„	Girls.	„
XVII.	Medium Eyes,	Boys.	„
XVIII.	„	Girls.	„
XIX.	Dark Eyes,	Boys.	VII.
XX.	„	Girls.	„

COUNTIES.

			Pl.
XXI.	Fair Hair,	Boys.	„
XXII.	„	Girls.	„
XXIII.	Red Hair,	Boys.	VIII.
XXIV.	„	Girls.	„
XXV.	Medium Hair,	Boys.	„
XXVI.	„	Girls.	„
XXVII.	Dark Hair,	Boys.	IX.
XXVIII.	„	Girls.	„
XXIX.	Jet Black Hair,	Boys.	„
XXX.	„	Girls.	„
XXXI.	Blue Eyes,	Boys.	X.
XXXII.	„	Girls.	„
XXXIII.	Light Eyes,	Boys.	„
XXXIV.	„	Girls.	„
XXXV.	Medium Eyes,	Boys.	XI.
XXXVI.	„	Girls.	„
XXXVII.	Dark Eyes,	Boys.	„
XXXVIII.	„	Girls.	„
XXXIX.	Fair Hair, Boys, Districts.		XII.
XL.	Red Hair, Boys, „		„
XLI.	Hair Colour, Local Divergencies, Boys, Divisions.		„
XLII.	Hair Colour, Local Divergencies, Girls, Divisions.		„
XLIII.	Hair Colour, Local Divergencies, Boys, Counties.		XIII.

		Pl.
XLIV.	Hair Colour, Local Divergencies, Girls, Counties.	XIII.
XLV.	Density of Population in Non-Divergent Counties.	„
XLVI.	Density of Population for each County in Scotland.	„
XLVII.	Hair Colour, Local Divergencies, Boys, Districts.	XIV.
XLVIII.	Hair Colour, Local Divergencies, Girls, Districts.	„
XLIX.	Eye Colour, Local Divergencies, Boys, Divisions.	„
L.	Eye Colour, Local Divergencies, Girls, Divisions.	„
LI.	Eye Colour, Local Divergencies, Boys, Counties.	XV.
LII.	Eye Colour, Local Divergencies, Girls, Counties.	„
LIII.	Eye Colour, Local Divergencies, Boys, Districts.	„
LIV.	Eye Colour, Local Divergencies, Girls, Districts.	„
LV.	Glasgow. Boys, Divergency in hair colour.	XXI.
LVI.	„ Girls, Divergency in hair colour.	„
LVII.	„ Boys, Divergency in eye colour.	„
LVIII.	„ Girls, Divergency in eye colour.	„
LIX.	„ Boys, Fair Hair.	XXII.
LX.	„ Girls, Fair Hair.	„
LXI.	„ Boys, Red Hair.	„
LXII.	„ Girls, Red Hair.	„
LXIII.	„ Boys, Medium Hair.	XXIII.
LXIV.	„ Girls, Medium Hair.	„
LXV.	„ Boys, Dark Hair.	„
LXVI.	„ Girls, Dark Hair.	„
LXVII.	„ Boys, Jet Black Hair.	XXIV.
LXVIII.	„ Girls, Jet Black Hair.	„
LXIX.	„ Boys, Blue Eyes.	„
LXX.	„ Girls, Blue Eyes.	„
LXXI.	„ Boys, Light Eyes.	XXV.
LXXII.	„ Girls, Light Eyes.	„
LXXIII.	„ Boys, Medium Eyes.	„
LXXIV.	„ Girls, Medium Eyes.	„
LXXV.	„ Boys, Dark Eyes.	XXVI.
LXXVI.	„ Girls, Dark Eyes.	„
LXXVII.	„ Key Map.	„
LXXVIII.	„ Key Map with Suburban areas.	„

DIAGRAMS.

Distribution of Relative Local Differences.

		Pl.
I.	Boys, Fair Hair.	XVI.
II.	„ Red Hair.	„
III.	„ Medium Hair.	„
IV.	„ Dark Hair.	„
V.	„ Jet Black Hair.	XVII.
XI.	„ Blue Eyes.	XIX.
XII.	„ Light Eyes.	„
XIII.	„ Medium Eyes.	„
XIV.	„ Dark Eyes.	„
VII.	Girls, Fair Hair.	XVIII.
VIII.	„ Red Hair.	„
IX.	Girls, Medium Hair.	XVIII.
X.	„ Dark Hair.	„
VI.	„ Jet Black Hair.	XVII.
XV.	„ Blue Eyes.	XX.
XVI.	„ Light Eyes.	„
XVII.	„ Medium Eyes.	„
XVIII.	„ Dark Eyes.	„
XIX.	Relationship between Density and Other Characteristics in the Population. See p. 189.	

TABLES.

		Page
I.	Analytical Table of Hair and Eye Colours . . .	132
II.	Schedule	134
III.	Counties (with Districts)	138
IV.	Returns Received . . .	140
V.	Class Ranges	146
VI.	Colour Distribution of Scottish Children	147
VII.	Relative Local Differences .	148
VIII.	„ „ „	149
IX.	„ „ „	150
X.	County Specification, Fair Hair, Both Sexes . .	152
XI.	County Specification, Red Hair, Both Sexes . .	153
XII.	County Specification, Medium Hair, Both Sexes . .	154
XIII.	County Specification, Dark Hair, Both Sexes . .	155
XIV.	County Specification, Jet Black Hair, Both Sexes .	157
XV.	County Specification, Blue Eyes, Both Sexes . .	158
XVI.	County Specification, Light Eyes, Both Sexes . .	159
XVII.	County Specification, Medium Eyes, Both Sexes . .	161
XVIII.	County Specification, Dark Eyes, Both Sexes . .	162
XIX.	Divergency in Hair and Eye Colour, Divisions . .	165
XX.	Divergency in Hair and Eye Colour, Counties . .	166
XXI.	Divergency in Hair Colour, Districts	167
XXII.	Divergency in Eye Colour, Districts	168
XXIII.	Comparative Densities of Population	169
XXIV.	Divergency in Hair Colour, Divisions, Counties and Districts	171
XXV.	Divergency in Eye Colour, Divisions, Counties and Districts	174
XXVI.	Interlocal Constants, Colour Heterogeneity . . .	176
XXVII.	Heterogeneity in Colour .	177
XXVIII.	Probability Table, Hair and Eye Colour . . .	178
XXIX.	Excess Positive Frequencies peculiar to great Divisions.	180
XXX.	Correlation Table, Gaelic Population and Jet Black Hair	183
XXXI.	Correlation, Hair and Eyes with Gaelic speaking Population	183

		Page
XXXII.	Density of Population, Divisions	185
XXXIII.	Foreigners in each great Division	185
XXXIV.	Correlations, Foreigners and Density	186
XXXV.	Correlations, Density and Pigmentation and Foreigners and Pigmentation	186
XXXVI.	Density and the Death Rate	187
XXXVII.	Correlations, Death Rate and Pigmentation	188
XXXVIII.	Colour Distributions, Irish, English and Scottish Adults	190
XXXIX.	Correlations, Births per family and Pigmentation	192
XL.	Associations, Colour Classes in the same Regions	196
XLI.	Classes, excesses of which are found together in the same Regions	196
XLII.	Relationships between Pigmentation and certain Defects	197
XLIII.	Relationship between the Gaelic speaking Population and Defects	198
XLIV.	Degree of Resemblance between the Boy and Girl Populations	199
XLV.	Observed and Expected Results, Glasgow and Govan	200
XLVI.	School Board Districts and Schools in Glasgow	202
XLVII.	Pigmentation groups of Greater Glasgow	203
XLVIII.	Frequencies of Colour Classes in Greater Glasgow	204
XLIX.	Relative Local Differences, Greater Glasgow and Environs	205
L.	Divergency in Hair and Eye Colour, Greater Glasgow and Environs	206
LI.	Specification of the Greater Glasgow Population	209
LII.	Condensed Specification of Greater Glasgow Population	210
LIII.	Number of Persons per square mile in Chief Towns of Scotland	212
LIV.	Population in 1901 of Chief Towns in Scotland	213
LV.	Foreign Surnames in Glasgow	214
LVI.	Colour Characters of Foreign Immigrants in Glasgow	214
LVII.	Colour Distribution of Children of Irish origin	216
LVIII.	Percentages of Children of Non-Scottish origin	216
LIX.	Relative Difference between East Aberdeenshire in 1896 and 1903	219
LX.	Comparative Table, British and Foreign Data	221
LXI.	Hair and Eye Colour, City of Aberdeen	224
LXII.	Correlation, Hair and Eyes, British and Foreign Data	225

VARIATION, DEVELOPMENT AND GROWTH IN HOLOTHURIA FLORIDANA POURTALÉS AND IN HOLOTHURIA ATRA JÄGER.

By CHARLES LINCOLN EDWARDS, of Trinity College,
Hartford, Connecticut.

CONTENTS.

Page
- I. Introduction 238
  - A. History. Conclusions announced in this Paper 238
  - B. Material and Methods of Study . 239
- II. *Holothuria floridana* Pourtalès . 241
  - A. Body 241
    - a. Form 241
    - b. Size 241
      - 1. Length in cm. . . . 241
      - 2. Diameter in cm. . . . 241
      - 3. Volume in cm.^{3} . . . 243
  - B. Development and Growth . . 243
  - C. Colour 244
    - a. Living and Alcoholic Specimens 244
    - b. Methods of Determination . 244
    - c. Colouration 246
      - 1. Pedicels and Papillae . . 246
      - 2. Distribution of Colour on the Body 247
  - D. Tentacles and Ampullae . . 248
    - a. Symmetry in Arrangement of Tentacles and Ampullae . 248
      - Variations from the Symmetry of the Tentacles of the Mid-dorsal Interradius in Relation to the Attachment of the Mesentery . 248
    - b. Number of Tentacles . . 249
      - Variation in the Number of Tentacles and the Relation of those present to the Normal Symmetry . . 249
    - c. Branches on Tentacular Ampullae and Variation in their Number 251
    - d. Variation in Size of Tentacles . 252
    - e. Development of Tentacles . 252

Page
  - E. Pedicels and Papillae . . . 252
    - a. Distribution per sq. cm. . . 253
    - b. Development and Appearance . 253
    - c. Warts 254
      - 1. Distribution of Warts . . 254
      - 2. Number of Warts on Sides of Bivium 255
    - d. Papillae around the Anus . 255
      - Distribution of Papillae around the Anus . . 255
  - F. Thickness of Body-wall . . 255
  - G. Calcareous Spicules of the Body-wall 256
    - a. Tables 256
      - 1. Development of the Table . 256
      - 2. Structure of the Table . . 257
      - 3. Variation in Crown and Vertical Rods. . . . 257
    - b. Tables of Bivium and Trivium in *H. floridana* . . . 257
      - 1. Disc 258
      - 2. Height 259
      - 3. Crown 259
    - c. Rosettes and Rosettes with Holes 260
    - d. Perforated Plates . . . 261
      - 1. Development of the Perforated Plate . . . 261
      - 2. Structure and Variation of the Developed Perforated Plates 262
    - e. Number of Rosettes and Perforated Plates . . . 263
    - f. Correlation of Rosettes and Perforated Plates with Advancing Age . . . 263

ERRATA.

P. 243. Table VI. Last column, the volume should be cubic mm. not $cm.^3$ as printed in text.

P. 295. C. Additional Characters of H. floridana. *Growth.* The volume of the embryo in the first four lines of this section should be given in cubic mm. not $cm.^3$ as printed in text.

Page
H. Calcareous Spicules of the Ambulacral Appendages and the Differentiation of Pedicels and Papillae 264
  a. Form 265
  b. Suckers 265
  c. End-plates 265
  d. Supporting Rods . . . 266
    1. Dorsal 266
    2. Ventral 266
  e. Association of Forms of Ambulacral Appendages with Types of End-plates . . . 266
  f. Association of Suckers with Types of End-plates . . 267
  g. Association of Supporting Rods with Types of End-plates . 267
  h. Conclusions and Definitions . 267
I. The Calcareous Ring . . . 268
J. Polian Vesicles 269
K. Stone-canals and Madreporites . 271
L. Gonads 273
M. Respiratory Trees . . . 273
N. The Enteric Canal . . . 273
O. Habitat 274
III. *Holothuria atra* Jäger . . . 274
A. Body 274
  a. Form 274
  b. Size 274
    1. Length in cm. . . . 274
    2. Diameter in cm. . . . 277
    3. Volume in cm.^{3} . . . 277
B. Colour 277
  a. Colouration 277
    1. Pedicels and Papillae . . 277
    2. Distribution of Colour on the Body 277
C. Tentacles and Ampullae . . 278
  a. Number of Tentacles . . 278
    Variation in the Number of Tentacles and the Relation of those present to the Normal Symmetry . . 278
  b. Branches on Tentacular Ampullae and Variation in their Number 279
D. Pedicels and Papillae . . . 279
  a. Distribution per sq. cm. . . 279
  b. Distribution of Papillae around the Anus 280
E. The Body-wall 280
Page
  a. Thickness in mm. . . . 280
  b. Pits 281
F. Calcareous Spicules of the Body-wall 282
  a. Tables 282
  b. Tables of Bivium and Trivium in *H. atra* 282
    1. Disc 283
    2. Height 283
    3. Crown 283
  c. Rosettes and Rosettes with Holes 283
    Number per sq. cm. . . 285
G. Calcareous Spicules of the Ambulacral Appendages and the Differentiation of Pedicels and Papillae 285
  a. Form 285
  b. Suckers 285
  c. End-plates 286
  d. Supporting Rods . . . 286
    Dorsal 286
  e. Supporting Rosettes and Supporting Plates. Ventral . 287
  f. Association of Form of Ambulacral Appendages with Types of End-plates in the Bivium 287
  g. Association of Suckers with Types of End-plates . . 287
  h. Association of Supporting Rods with Types of End-plates . 287
  i. Conclusions and Definitions . 288
H. The Calcareous Ring . . . 288
I. Polian Vesicles 288
J. Stone-Canals and Madreporites . 289
K. Gonads 290
L. Respiratory Trees . . . 290
M. The Enteric Canal . . . 290
N. Habitat 290
IV. Summary 292
A. Characters separating *H. floridana* Pourtalès (= *H. mexicana* Ludwig, *H. africana* Théel) from *H. atra* Jäger 292
B. Characters Common to the Two Species 294
C. Additional Characters of *H. floridana* 295
D. Additional Characters of *H. atra* 296
  Literature cited 297
  Explanation of Plates . . 300

I. INTRODUCTION.

A. History of the Subject. Conclusions announced in this Paper.

Pourtalès, 1851, p. 12, described the Holothurid from the muddy flats of the Florida Keys as *Holothuria floridana.* This was recognized as a valid species by Selenka, 1867, pp. 324–6, Pl. 18, Figs. 47–50, but this author probably included part of *H. atra* Jäger, 1833, pp. 22–3, Pl. 3, Fig. 2, in his *floridana.* After investigating a good number of specimens from Florida and the Pacific Ocean, Selenka notes differences in (1) size of calcareous ring, (2) number of ventral pedicels in old individuals, (3) size of end-discs, and (4) number and size of stone-canals, but he concludes that such differences, being only of relative size and not of form, give no ground for specific separation.

Semper, 1868, pp. 88, 92, 278–9, made of Selenka's *atra* the variety *amboinensis* and gave the *floridana* of Pourtalès as a synonym of *H. atra* from Celebes described by Jäger. Since then all authors have followed Semper in relegating *H. floridana* to the synonymy of *H. atra.*

Ludwig, 1874, p. 101, described *H. mexicana* from one small specimen (6 cm. long), without gonads, in the Hamburg Museum under the rather indefinite locality-label of "Mexico." Clark, 1901, p. 258, identified specimens from Porto Rico as *H. mexicana* Ludwig. I have 10 of Clark's specimens included in the series from which my statistics were taken and they are in all respects like the average *H. floridana* as determined in this paper. Hérouard, 1902, p. 8, identified 2 specimens from the Azores as *H. mexicana,* although in some doubt from the fact that the spicules had been dissolved.

Clark, 1902, p. 530, places specimens from Clipperton Island under *H. atra* (Jäger) but is "confident that no less than three distinct species are now included under that name."

Théel, 1886, pp. 174–5, Pl. 8, Fig. 7, described a single specimen from Simon's Bay, Africa, as *H. africana,* and at the end of his description said, "The species in question is possibly identical with Ludwig's *Holothuria mexicana.*" In view of the facts established by my studies, I believe we must confirm Théel's suggestion in making *H. africana* and *H. mexicana* identical, and further that the species common from Florida to the Caribbean region is distinct from *H. atra* and therefore, to designate it, the name *H. floridana* Pourtalès should be re-established (Edwards, 1905). The small individual described by Ludwig is, without doubt, a young *H. floridana,* and so *H. mexicana* Ludwig = (*H. africana* Théel) becomes a synonym of *H. floridana* Pourtalès.

The validity of Semper's variety *amboinensis* was questioned by Ludwig, 1883, and denied by Lampert, 1885, and Sluiter, 1902. The last author examined a series of 21 specimens from 12 localities, and found all the intermediate stages from *H. atra* to the variety *amboinensis.* My studies show that the characters given for the variety have no validity.

B. Material and Methods of Study.

The material subjected to a statistical analysis for this paper includes 138 specimens from the collections of the U.S. National Museum, the Museum of Comparative Zoology, Harvard University, and my own series. For their courtesy in placing specimens in my hands for study, I desire to express my thanks to Dr Richard Rathbun, Assistant Secretary of the Smithsonian Institution, and Dr J. E. Benedict, Assistant Curator, Division of Marine Invertebrates of the U.S. National Museum; and to Dr Alexander Agassiz, Director, Dr W. McM. Woodworth, Assistant, and Dr H. L. Clark, Curator of Echinoderms, of the Museum of Comparative Zoology, Harvard University. I would acknowledge my indebtedness to Dr Charles B. Davenport for his counsel, and also express my appreciation of the skilful and conscientious aid rendered by my assistant, Mr Hubert Dana Goodale.

The various taxonomic characters have been analysed by the biometric methods whose development and application to biological problems are due so largely to the work of Francis Galton and Karl Pearson. In biometry it is important to separate the young specimens from the adult. In the Holothuroidea it is evident that both length and breadth combined in volume must be considered in judging the age. The formula, volume of cylinder $= \pi l r^2$, was adjusted to the more or less shrunken body of the alcoholic specimen and its natural departure from the cylindrical form, by the measurement of the volume of ten individuals in water displacement. It was thus found that the average actual volume is 50 per cent. of the volume estimated by the above formula. Hence I have used the formula $\frac{\pi l r^2}{2}$ to determine the approximate volume of the specimens studied. Mitsukuri, 1903, pp. 13—19, concludes that individuals of *Stichopus japonicus* Selenka taken during the spring and early summer divide themselves into three lots; (1) the adult, (2) the second-year young and (3) the first-year young. From Mitsukuri's tables, in which lengths and diameters are given, I find with the formula $\frac{\pi l r^2}{2}$ that the average volume of the "second-year young" of *Stichopus japonicus* is 113·99 c.c. Mitsukuri concludes "that *Stichopus japonicus* reaches the adult condition in two whole years" therefore the "second-year young," while not sexually mature, are of adult rather than young size. The average volume of the "first-year young" is 43·16 c.c.

In *H. atra* and *H. floridana* I have included in the adult category all of 50 c.c. or greater volume*, realising that such an exact line of division is, to a certain extent, arbitrary, and yet that it is near enough to nature to give in a broad manner the average adult characters for comparison with those of the first-year young. Since it is possible that some of the specimens included in the class may be slightly beyond the first-year I will use simply the general term *young* to designate the group.

---

* One specimen of *H. atra*, volume 49·46 c.c. is given as adult.

Mitsukuri, 1897, demonstrated that with advancing age the spicules in *Stichopus japonicus* change so much that "the form distinguished by Théel as var. *typicus* is only a stage in the growth of the species," and from the results of my work I would emphasize Mitsukuri's conclusion as to the important bearing such facts have upon the description of species and the classification of Holothuroidea.

Ludwig, 1898, found in *Phyllophorus urna* that the spicules pass from an Elasipod larval stage to the typical generic type and then, in old age, to secondary rosettes. This author (1898a) also proved in *Cucumaria laevigata* a change in the spicules with advancing age. Östergren, 1898, believed that *Holothuria aphanes* represents the young of *Holothuria impatiens*. The spicules of the former type disappear in the larger specimens and then later are replaced by those peculiar to *Holothuria impatiens*.

Of the 138 specimens available for this paper, 118 are *H. floridana* Pourtalès from the Bahamas, the Florida Keys, Tortugas, Cuba, Porto Rico, Haiti, St Thomas, Swan and Curacoa Islands, Caribbean Sea, and 20 are *H. atra* Jäger from Zanzibar, Mozambique, Arabian Sea, Marshal Is., Samoa, Society Is., Tahite and Hawaiian Is. After completing this study, I have examined specimens from the Galapagos Is. now in the collection of Dr H. L. Clark, which thus extends the range of *H. atra* across the entire Indo-Pacific Ocean.

Simon's Bay, at the Cape of Good Hope, the locality of Théel's *H. africana* is beyond the reported limit of *H. atra* toward that of *H. floridana*. Adopting *H. africana* as a synonym of *H. floridana* it would be interesting to learn whether this species occurs at any places between the southern point of Africa and the Caribbean Sea.

To facilitate comparison, under each character studied I have placed side by side the values for adult and young of the biometric constants, mean, standard deviation or index of variability, and coefficient of variation, each followed by its probable error (±) and at the end the total range of variation of the character. The formulae as given by Davenport, 1904, were used. For graduated variates and integral variates with a class range of more than one, the classes are named from their middle values. For graduated variates with a class range of one, or less than one, the classes are named from their minimum values. The adjectives dorsal and ventral refer to the bivium and trivium respectively. The data for *H. floridana* are presented first, then those for *H. atra* together with comparisons between the two species.

In the summary are given the differential characters which define *H. floridana* Pourtalès and *H. atra* Jäger and upon which I base the re-establishment of the former as a valid species. Finally there is a brief résumé of the additional facts concerning development, growth and variation in common for the two species and then such as are peculiar to each.

TABLE I.

H. floridana Pourtalés, *Adult.*

Serial Number	Length cm.	Diameter cm.	Volume cm.³	Average Thickness of Skin mm.	Sex	NUMBER OF WARTS		POLIAN VESICLES														STONE CANALS					NUMBER		PEDICELS AND PAPILLAE; DISTRIBUTION PER SQ. CM.		MUSEUM NUMBER		
								In Tufts		In Tufts with Branched Vesicles				Solitary			Total Number			Length mm.		Number			Length								
														Branched		Simple																	
						Right	Left	Number of Tufts	Number of Vesicles in each Tuft	Number of Tufts	Number of Simple Vesicles in each Tuft	Number of Branched Vesicles in each Tuft	Number of Branches	Number of Vesicles	Number of Branches	Number of Vesicles	Vesicles	Branches	Vesicles and Branches	Greatest	Least	Right	Left	Totals	Greatest	Average	Tentacles	Groups of Anal Papillae	Dorsal	Ventral	U.S. National Museum	Harvard	Edwards
1	18·0	7·6	408·56	5·0	♀	0	0	—	—	—	—	—	—	1	13	1	2	13	15	37	1	13	10	23	10	6·5	19	5	12	37	—	—	1
2	19·0	5·8	251·00	4·0	♀	15	17	1	2	—	—	—	—	—	—	3	8	—	—	37	2	25	9	34	12	7·0	20	i	13	31	—	—	2
								1	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
3	20·6	5·2	218·75	5·0	♂	×	×	—	—	—	—	—	—	1	1	12	15	5	20	40	2	33	36	69	6	4·0	20	i	22	39	—	—	3
														1	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
														1	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
4	18·3	5·0	179·66	5·0	♀	0	0	1	2	—	—	—	—	—	—	3	27	—	—	23	2	10	19	29	13	8·5	20	5	12	21	—	—	0a
								1	5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
								1	7	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
								1	10	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
5	19·0	3·6	96·70	2·0	♂	×	×	1	5	—	—	—	—	1	5	—	6	5	11	13	7	20	19	39	21	7·5	16	5	18	34	—	—	0b
6	16·0	3·6	81·44	3·5	♀	×	×	1	2	—	—	—	—	—	—	1	5	—	—	20	2	11	5	16	6	4·5	18	5	16	17	—	—	0c
								1	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
7	14·7	4·1	97·04	2·0	♀	×	×	—	—	—	—	—	—	—	—	3	3	—	—	14	2	10	5	15	14	5·5	20	6	17	23	—	—	0e
8	14·0	4·7	121·45	3·0	♂	×	×	—	—	—	—	—	—	—	—	1	1	—	—	19	—	14	7	21	9	6·0	20	5	16	34	—	—	4a
9	13·5	3·4	61·29	2·5	♂	×	×	—	—	1	—	1	1	—	—	2	4	2	6	19	4	14	4	18	10	4·0	20	5	18	31	—	—	4b
												1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
10	17·3	3·7	84·36	3·0	♂	×	×	—	—	—	—	—	—	1	1	3	4	1	5	21	2	25	25	50	4	3·5	20	4	16	25	—	—	4c
11	20·0	5·0	196·35	3·5	♂	×	×	2	2	1	3	—	—	1	2	9	41	4	45	30	1	16	14	30	21	10·5	20	5	10	22	—	—	4d
								3	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
								2	4	—	—	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
								1	5	—	—	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
12	15·2	4·5	120·88	3·5	♀	5	6	1	2	—	—	—	—	1	1	2	5	1	6	17	3	23	27	50	12	6·0	20	5	13	41	—	—	6a
13	12·2	3·8	69·18	2·0	?	15	19	1	9	—	—	—	—	—	—	1	10	—	—	8	1	8	9	17	6	4·5	20	4	13	41	—	—	0d
14	11·4	5·3	130·55	3·0	♀	9*d*	6*d*	1	2	—	—	—	—	—	—	2	4	—	—	24	3	12	16	28	8	4·5	20	5	15	32	—	—	0f
15	17·4	7·5	384·36	4·5	♂	×	×	1	4	—	—	—	—	—	—	5	15	—	—	31	2	15	21	36	16	8·0	20	i	12	35	14714	—	—
								1	6	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
16	19·2	5·7	244·97	3·5	♂	6	4	4	2	—	—	—	—	1	3	31	58	8	66	22	1	42	27	69	8	6·5	20	5	12	35	14714	—	—
								1	3	—	—	—	—	1	5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
								1	4	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
								2	5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
17	23·8	4·1	157·11	4·5	♂	×	×	1	2	1	2	1	2	1	1	20	79	13	92	22	1	16	4	20	15	7·0	20	5	14	29	14715	—	—
								2	3	—	—	1	1	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
								3	4	1	2	1	3	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
								2	6	—	—	1	4	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
								1	7	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
18	22·1	3·9	132·00	4·0	♂	7	6	1	5	1	1	1	1	1	1	3	12	3	15	29	1	21	45	66	14	9·5	20	3	12	21	14715	—	—
														1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
19	22·1	7·3	462·49	—	♀	0	0	—	—	—	—	—	—	—	—	—	—	—	23	22	1	56	27	83	7	5·0	22	5	15	30	—	1057	—
20	19·2	5·2	203·88	—	♂	11	7	—	—	—	—	—	—	—	—	—	—	—	10	28	1	8	6	14	7	5·5	18	5	14	29	—	"	—
21	16·0	4·9	150·86	—	♂	7	10	—	—	—	—	—	—	—	—	—	—	—	19	13	8	10	6	16	5	4·0	20	4	12	33	—	"	—
22	13·3	4·4	101·12	—	♂	6	7	—	—	—	—	—	—	—	—	—	—	—	2	30	—	10	6	16	9	6·5	20	4	10	30	—	"	—
23	12·0	3·8	68·05	—	♂	×	×	—	—	—	—	—	—	—	—	1	1	—	—	51	—	9	4	13	6	4·5	20	i	16	50	—	"	—
24	24·0	7·0	461·82	3·5	♀	0	0	—	—	—	—	—	—	—	—	—	—	—	25	30	1	23	21	44	5	3·5	20	c	12	32	—	614	—
25	31·0	6·4	498·64	—	+	0	0	—	—	—	—	—	—	—	—	—	—	—	11	53	3	39	44	83	10	8·0	20	5	10	22	—	592	—
26	22·3	4·2	164·48	—	♀	0	0	—	—	—	—	—	—	—	—	—	—	—	7	17	1	10	8	18	5	4·0	20	5	7	6	16720	—	—
27	10·[illegible]	3·6	53·44	2·5	♀	0	0	—	—	—	—	—	—	—	—	3	3	—	—	22	5	11	5	16	3	2·5	20	5	10	17	—	—	7a
28	11·0	3·7	53·64	4·5	♂	9	8	—	—	—	—	—	—	—	—	1	1	—	—	11	—	5	2	7	7	5·5	18	?	14	20	—	—	7b
29	9·8	3·8	55·57	2·0	♀	0	0	—	—	—	—	—	—	—	—	1	1	—	—	16	—	7	3	10	4	3·5	20	5	9	22	—	—	7d
30	[illegible]	6·7	306·73	13·0	♀	×	×	—	—	—	—	—	—	—	—	2	2	—	—	14	3	63	18	81	10	5·0	21	5	11	16	16717	—	—
31	22·2	5·7	283·25	10·0	♀	×	×	—	—	—	—	—	—	1	4	—	1	4	5	13	—	21	14	35	7	6·0	20	5	7	9	"	—	—
32	21·2	4·8	191·82	6·5	♀	0	0	1	2	—	—	—	—	—	—	7	9	—	—	35	2	39	21	60	5	4·0	20	5	12	17	"	—	—
33	19·3	6·1	282·02	5·5	♂	0	0	—	—	—	—	—	—	—	—	1	1	—	—	23	—	33	23	56	5	4·0	20	4	12	17	"	—	—
34	18·0	4·8	162·86	10·0	♀	×	×	1	4	—	—	—	—	—	—	—	4	—	—	30	3	21	20	41	5	3·0	22	5	10	15	"	—	—
35	11·[illegible]	4·1	75·92	2·0	?	×	×	—	—	—	—	—	—	—	—	3	3	—	—	21	1	16	11	27	4	3·0	19	5	10	26	16712	—	—
36	14·1	4·2	97·68	3·5	♀	*d*	*d*	—	—	—	—	—	—	—	—	—	—	—	9	40	1	18	14	32	6	5·0	20	i	17	40	—	?	—
37	16·8	6·0	229·03	7·0	♀	0	0	—	—	—	—	—	—	—	—	1	1		—	?	?	7	8	15	8	7·0	19	5	18	34	—	?	—
38	18·0	6·3	271·56	1·5	♂	0	0	—	—	—	—	—	—	—	—	—	—	—	17	24	2	46	18	64	7	6·5	20	5	16	28	—	?	—
39	17·1	3·7	91·93	3·0	♂	×	×	1	2	—	—	—	—	—	—	1	3	—	—	23	5	4	1	5	4	3·0	20	5	18	13	16721	—	—
40	19·0	5·1	194·07	2·0	♀	×	×	—	—	—	—	—	—	—	—	1	1	—	—	28	—	18	21	39	5	4·0	18	4	12	16	16697	—	—
41	13·8	3·4	62·65	1·5	♂	×	×	—	—	—	—	—	—	—	—	1	1	—	—	16	—	22	4	20	4	3·0	19	4	15	22	"	—	—
42	13·7	3·3	58·75	2·5	♀	11*d*	9*d*	—	—	—	—	—	—	—	—	1	1	—	—	25	—	9	4	13	5	3·5	20	i	10	16	16698	—	—
43	13·2	3·2	53·08	2·0	♀	8	5	—	—	—	—	—	—	—	—	1	1	—	—	25	—	5	2	7	7	4·5	20	5	13	23	16699	—	—
44	21·4	4·0	134·46	2·5	♂	8	10	—	—	—	—	—	—	—	—	1	1	—	—	28	—	15	11	26	4	3·5	20	5	8	16	16697	—	—
45	18·4	4·4	139·89	3·0	♂	10	10	—	—	—	—	—	—	—	—	3	3	—	—	32	3	13	7	20	4	3·0	18	c	9	16	"	—	—
46	16·0	4·4	121·64	2·0	♀	8	6	—	—	—	—	—	—	—	—	—	?		—	?	—	12	6	18	7	5·5	20	5	9	21	16892	—	—
47	19·1	4·1	126·09	3·5	♀	×	×	1	3	—	—	—	—	—	—	4	7	—	—	38	1	13	9	22	6	5·0	20	5	9	15	16716	—	—
48	14·0	3·4	63·56	7·0	♀	13	15	—	—	—	—	—	—	—	—	4	4	—	—	30	1	9	5	14	7	6·0	20	5	13	20	"	—	—
49	9·7	3·7	52·15	1·0	♀	14	9	—	—	—	—	—	—	—	—	—	?	—	—	—	—	4	3	7	5	4·0	20	5	10	20	16699	—	—
50	15·0	5·7	191·38	—	♀	0	0	—	—	—	—	—	—	—	—	—	—	—	6	58	1	27	9	36	10	7·0	20	i	17	39	—	1001	—
51	18·5	7·0	355·99	—	♂	6	5	—	—	—	—	—	—	—	—	—	—	—	12	40	1	20	11	31	10	7·0	20	i	22	32	—	614	—
52	11·3	4·3	82·05	2·0	♂	0	0	—	—	—	—	—	—	—	—	2	2	—	—	26	10	6	5	11	5	4·5	19	5	15	20	—	405	—
53	9·0	3·8	51·04	1·5	♀	0	0	—	—	—	—	—	—	—	—	1	1	—	—	19	—	9	3	12	3	2·5	20	5	10	21	—	36	—
54	10·0	3·9	59·73	3·0	♀	0	0	—	—	1	3	1	1	—	—	11	15	1	16	19	2	16	21	37	5	4·0	20	6	13	25	19669	—	—
55	16·0	4·8	144·76	3·5	♂	0	0	—	—	—	—	—	—	1	3	11	12	3	15	16	1	51	15	66	5	4·5	19	5	14	18	"	—	—
56	25·2	7·0	484·91	1·0	♂	6	5	—	—	—	—	—	—	—	—	19	19	—	—	8	1	17	15	32	6	5·0	20	5	10	14	"	—	—
57	16·1	3·9	88·12	1·5	♂	0	0	1	2	—	—	—	—	—	—	5	7	—	—	17	1	18	10	28	3	1·5	19	5	11	15	"	—	—
58	15·6	7·7	355·42	2·5	♂	×	×	—	—	—	—	—	—	—	—	3	3	—	—	10	8	29	28	57	5	3·5	20	4	6	14	"	—	—
59	18·5	5·8	244·40	4·0	♂	×	×	1	3	—	—	—	—	—	—	16	37	—	—	22	1	23	20	43	13	6·5	20	5	13	30	19667	—	—
								1	5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
								2	7	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
60	26·7	6·4	429·47	2·5	♀	×	×	—	—	—	—	—	—	—	—	4	4	—	—	14	1	11	24	35	11	7·5	20	5	13	23	19667	—	—
61	17·5	5·6	215·52	7·5	♀	0	0	—	—	—	—	—	—	1	2	6	7	2	9	28	1	52	34	86	11	5·5	21	i	11	18	19672	—	—
62	14·9	5·3	164·36	6·0	♂	0	0	—	—	1	1	1	4	1	2	4	7	6	13	19	1	25	14	39	8	4·5	21	i	13	26	"	—	—
63	15·0	3·3	64·09	1·0	♀	0	0	—	—	—	—	—	—	—	—	12	12	—	—	23	1	28	24	52	3	3·0	18	5	20	23	19673	—	—
64	24·5	8·1	631·15	6·0	♂	×	×	—	—	—	—	—	—	—	—	—	—	—	8	16	9	30	22	52	8	7·0	20	i	11	22	—	132	—
65	32·4	7·7	754·40	—	♀	0	0	—	—	—	—	—	—	—	—	—	—	—	29	15	1	43	21	64	5	5·0	20	5	17	24	—	74	—
66	32·7	8·3	884·64	—	♂	0	0	—	—	—	—	—	—	—	—	—	—	—	14	14	1	35	38	73	8	7·0	19	c	11	27	—	74	—
67	20·9	6·1	305·40	5·0	♂	0	0	3	2	—	—	—	—	—	—	4	13	—	—	20	1	15	26	41	7	5·0	20	5	10	25	7501	—	—
								1	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
68	19·6	6·0	277·09	3·5	♀	0	0	1	2	—	—	—	—	—	—	19	24	—	—	31	1	88	61	149	6	4·5	20	2	13	36	7501	—	—
								1	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
69	17·2	7·0	330·97	5·0	♀	×	×	—	—	—	—	—	—	—	—	13	13	—	—	31	1	32	23	55	6	4·5	20	5	14	30	7502	—	—
70	16·2	7·3	339·02	7·0	♀	×	×	3	2	1	3	1	1	1	1	13	31	2	33	16	1	24	39	63	5	4·0	20	5	13	26	"	—	—
								1	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
								1	4	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
71	14·4	3·6	73·29	3·5	♂	11	9	—	—	—	—	—	—	—	—	3	3	—	—	18	2	7	5	12	6	5·5	20	i	19	26	17064	—	—
72	15·4	7·2	313·51	5·5	♂	0	0	1	2	—	—	—	—	1	1	10	14	6	20	73	1	34	18	52	10	6·0	20	0	13	22	7427	—	—
										—	—	—	—	1	5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
73	18·4	6·0	260·13	5·5	♂	0	0	3	2	1	1	1	2	—	—	16	40	2	42	37	1	26	20	46	9	7·5	21	c	12	26	7427	—	—
								1	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
								2	4	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
								1	5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

? Missing. + Undifferentiated. × Traces. *d* Some in bivium. *i* Indefinite. *c* In a circle. In *40* the Polian vesicle arises from the right dorsal radial canal just below the calcareous ring. In *12*, 2 stone-canals arise 2 mm. from main tuft. *9* has several madreporites united. *11* has one stone-canal with 2 branches. *32* has an extra ventral tuft of 4 stone-canals. *1—14*, Bahamas, Abaco, Green Turtle Cay; *15—16*, New Providence; *17—18*, New Providence Nassau; *19—23*, under label, "Bermudas," but the Harvard records show that Dr H. Bryant, who presented these specimens, collected in the Bahamas and since Clark, 1899, pp. 122—3, says *H. floridana* does not occur in the Bermudas, I have seriated the specimens as Bahaman; *24—*[illegible], Florida; [illegible]*—26*, Florida; *27—29*, Elliots' Key; *30—34*, Caesar's Creek; *35*, Vaca Key; *36—38*, Bahia Honda; *39*, between Salt Pond Key and Stock Is.; *40—49*, Key West; *50—53*, Tortugas; *54—63*, Porto Rico; *54—58*, Boqueron Bay; *59—60*, Fajardo; *61—62*, Mayaquez; *63*, San Juan; *64*, Hayti; *65—70*, St Thomas; *71—73*, Caribbean Sea; *71*, Swan Is.; *72—73*, Curacoa I.

Originally *24*, *25* and *51* were identified as *Müllera agassizi* Selenka; *50*, *52*, *53* and *64* as *Holothuria floridana* Pourtalés; *54—63* as *H. mexicana* Ludwig, and the others of the Harvard and U.S. National Museums as *H. atra* Jager.

73	18·4	6·0	260·13	5·5	♂	0	0	3 1 2 1	2 3 4 5	1 — — —

? Missing. + Undifferentiated. × Traces. *d* Some in bivium. *i* Inde
united. *11* has one stone-canal with 2 branches. *32* has an extra ventral tuft of
who presented these specimens, collected in the Bahamas and since Clark, 1899,
Key; *36—38*, Bahia Honda; *39*, between Salt Pond Key and Stock Is.; *40—49*,
72—73, Curacoa I.

Originally *24*, *25* and *51* were identified as *Mülleria agassizii* Selenka; *50*, *52*,

To face p. 239

II. HOLOTHURIA FLORIDANA POURTALÉS.

A. Body.

a. FORM.

The cylindrical body tapers somewhat more posteriorly than anteriorly and is flattened in the trivium upon which it generally creeps. At the anterior end the mouth is ventral while the anus is terminal posteriorly. As the Holothurid pushes itself along over the slimy whitish coralline sand of the bottom, from the low tide mark to one, or a few fathoms, in depth, pieces of dead water-weeds, small shells and calcareous debris are caught up among the dorsal ambulacral appendages and serve as an excellent protective mask.

b. SIZE.

TABLE III.

1. *Length in cm.*

Alcoholic specimens measured while straightened out on a table and placed between two glass plates.

	Adult	Young
Number of specimens ...	73	45
Mean	17·656 ± ·390	6·694 ± ·344
Standard Deviation ...	4·939 ± ·276	3·517 ± ·240
Coefficient of Variation ...	29·972 ± 1·561	52·541 ± 3·736
Range of Variation ...	9—32·7	1·7—15·4

Selenka, 1867, p. 325, gives several individuals 35 cm. long.

TABLE IV.

2. *Diameter in cm.*

Greatest obtainable taken with a pair of dividers.

	Adult	Young
Number of Specimens ...	73	45
Mean	5·149 ± ·120	1·983 ± ·071
Standard Deviation ...	1·512 ± ·084	·816 ± ·047
Coefficient of Variation ...	29·361 ± 1·640	40·614 ± 2·878
Range of Variation ...	3·2—8·3	·6—3·4

TABLE II. *H. floridana* *Pourtalès.* *Young.*

Serial Number	Length cm.	Diameter cm.	Volume cm.^{3}	Average Thickness of Skin mm.	Sex	Number of Warts		Total Number Polian Vesicles	Length mm.		Stone Canals					Tentacles	Groups of Anal Papillae	Pedicels and Papillae Distribution per sq. cm.		Smithsonian Institution	Harvard	Edwards
											Number			Length mm.								
						Right	Left		Greatest	Least	Right	Left	Total	Greatest	Average			Dorsal	Ventral			
74	7·3	2·4	16·51	2·0	♂	10	9	1	18	—	3	1	4	7	5·0	20	5	17	40	14713	—	—
75	7·7	2·5	18·90	1·5	♀	7	0	1	17	—	6	4	10	7	4·5	20	5	18	41	"	—	—
76	10·0	2·9	33·03	1·5	♂	10	12	1	29	—	10	5	15	7	6·0	20	5	11	28	"	—	—
77	4·4	1·3	2·92	0·7	+	12	6	1	14	—	5	4	9	3	3·0	18	5	40	128	"	—	—
78	6·2	2·3	12·88	0·5	♂	9	9	1	11	—	6	4	10	4	3·5	20	*i*	40	60	"	—	—
79	9·5	2·6	25·22	1·5	♂	0	5	2	12	11	13	2	15	7	5·0	20	*i*	19	45	"	—	—
80	10·1	3·4	45·85	1·5	♀	9	9	2	15	14	10	7	17	6	5·0	18	5	9	23	"	—	—
81	9·6	3·0	33·93	2·0	♂	10	10	1	25	—	5	2	7	7	4·5	20	5	11	28	"	—	—
82	2·3	1·1	1·08	1·0	♂	5	5	2	4	1	5	0	5	2	2·0	18	5	34	48	14715	—	—
83	11·0	2·7	31·49	3·0	♂	×	×	1	8	—	15	4	19	6	6·0	20	5	20	19	—	200	—
84	6·5	1·7	7·38	3·0	♂	6	8	1	14	—	6	3	9	3	3·0	20	5	20	68	—	662	—
85	7·0	1·6	7·04	2·0	+	×	×	4	4	1	4	1	5	1	1·0	20	5	26	36	—	230	—
86	15·5	1·9	21·98	—	?	8	10	5	7	2	1	1	2	2	1·5	20	4	20	40	—	230	—
87	8·1	3·1	26·52	2·5	♂	7	7	1	10	—	6	5	11	5	4·5	20	*i*	10	12	—	—	7*c*
88	8·4	1·6	8·45	2·5	♀	*d*	*d*	1	2	—	14	11	25	3	2·0	19	5	22	14	16166	—	—
89	5·0	1·4	3·85	1·5	♀	7	8	1	5	—	8	2	10	2	1·0	18	5	23	35	"	—	—
90	5·0	1·6	5·03	0·7	♀	6	9	2	5	3	5	3	8	3	2·0	20	5	17	13	"	—	—
91	15·4	2·5	37·80	2·5	♂	12	11	3	13	8	7	8	15	5	2·0	20	*i*	12	18	16714	—	—
92	10·6	2·8	32·64	2·5	♂	14	12	1	26	—	12	9	21	3	3·0	20	4	15	28	16712	—	—
93	8·6	1·9	12·19	0·3	♀	11	10	1	6	—	3	1	4	3	3·0	20	5	16	27	16698	—	—
94	8·9	2·7	21·03	1·0	♀	7	5	1	15	—	3	2	5	4	3·5	20	5	12	20	"	—	—
95	9·4	2·6	24·95	2·0	+	10	10	1	?	—	1	3	4	7	5·0	20	*i*	35	45	"	—	—
96	5·6	2·1	9·70	1·0	♀	8	7	1	9	—	3	3	6	4	3·0	20	3	18	27	16706	—	—
97	3·6	1·5	3·18	0·1	+	8	8	1	6	—	2	2	4	1	1·0	19	5	14	28	"	—	—
98	3·9	1·5	3·45	0·5	?	7	5	1	6	—	4	3	7	3	2·0	20	5	17	27	16709	—	—
99	3·1	1·6	3·12	1·0	+	5	8	1	5	—	6	2	8	1	1·0	20	5	16	28	"	—	—
100	2·8	1·1	1·33	0·2	+	×	×	1	4	—	2	2	4	1	1·0	20	5	19	44	"	—	—
101	2·9	1·4	2·23	0·4	+	5	6	1	5	—	5	2	7	2	1·5	20	5	23	42	"	—	—
102	1·7	0·8	0·43	0·1	?	3	4	1	2	—	2	1	3	1	1·0	19	4	26	30	"	—	—
103	1·8	0·8	0·46	0·1	?	0	0	1	3	—	2	2	4	1	1·0	20	5	20	36	"	—	—
104	1·8	0·6	0·26	0·1	?	4	4	1	3	—	3	2	5	1	1·0	20	0	44	60	"	—	—
105	3·0	1·1	1·43	1·0	+	10	7	1	6	—	2	5	7	2	2·0	20	5	32	46	"	—	—
106	1·9	1·0	0·75	1·0	?	1	3	1	2	—	4	5	9	1	1·0	20	5	26	40	7556	—	—
107	1·8	0·8	0·46	1·0	?	*i*	8	1	4	—	2	1	3	1	1·0	20	*i*	28	36	"	—	—
108	7·3	2·0	11·47	1·0	♀	7	4	4	11	1	7	5	12	2	2·0	20	5	14	22	16702	—	—
109	6·6	2·3	13·71	1·0	+	×	×	1	12	—	11	5	16	3	2·0	20	5	14	19	"	—	—
110	3·9	1·2	2·21	1·0	+	3	8	0	—	—	4	1	5	3	3·0	20	4	21	29	"	—	—
111	5·8	2·0	9·11	1·5	+	9	11	1	12	—	5	1	6	2	1·0	19	6	24	22	"	—	—
112	10·6	3·3	40·03	1·5	♀	7	3	16	19	1	11	5	16	3	2·5	20	*i*	12	13	16699	—	—
113	10·7	2·8	32·95	1·0	♀	6	7	6	23	2	13	6	19	3	3·0	21	5	16	20	16892	—	—
114	8·0	2·5	15·64	2·0	♂	9	8	2	9	2	9	4	13	2	1·0	20	5	22	36	—	587	—
115	4·0	1·5	3·54	1·5	+	10	11	1	7	—	5	3	8	1	1·0	20	5	30	64	—	587	—
116	7·7	2·0	12·10	2·0	♂	10	8	8	10	2	4	4	8	5	4·0	20	5	19	59	—	587	—
117	7·9	2·8	24·33	2·0	♂	12	9	1	13	—	7	5	12	3	2·0	20	5	16	24	—	—	—
118	9·8	3·0	34·64	2·0	♀	×	×	1	6	—	11	4	15	5	4·5	20	5	8	11	—	—	—

? missing. + undifferentiated. × traces. *d* some dorsally. *i* indefinite. In 75 the Polian vesicle is near the mesentery on the left side. 112 has 1 tuft with 2 Polian vesicles and 113 has 1 tuft with 3 vesicles. 74, 81, 87—89, 91, 96 and 97 have warts on the bivium in addition to the right and left lateral rows and 76 has one row in the region of each dorsal radius. 74—81 from Abaco. 82, Nassau, New Providence, Bahamas. 83—116, Florida: 83—86, Cape Florida; 87, Elliot's Key; 88—90, Key Largo; 91, Indian Key; 92, Vaca Key; 93—113, Key West; 114—116, Tortugas. 117, 118, Havana, Cuba. 83—87 were originally identified as *Holothuria floridana* Pourtalès, the others as *H. atra* Jäger.

TABLE V.

3. *Volume in cm.*^{3} $v = \frac{\pi l r^2}{2}$

	Adult	Young
Number of Specimens ...	73	45
Mean	209·584 ± 13·185	12·506 ± ·645
Standard Deviation ...	167·025 ± 9·323	6·511 ± ·463
Coefficient of Variation ...	79·679 ± 4·450	52·076 ± 3·701
Range of Variation ...	51·04—884·64	·26—45·85

B. Development and Growth.

During the summer of 1888 I reared the young of this species at Green Turtle Cay, Abaco, Bahamas, (Edwards, 1889)*. During the first 5 days the embryo

TABLE VI.

Age in Days	Number of Specimens	Length mm.	Average Diameter mm.	Volume cm.^{3} $\left(\frac{\pi l r^2}{2}\right)$
5	3	·33	·28	·0102
7	3	·31	·25	·0076
9	3	·30	·27	·0086
10	3	·27	·27	·0077
11	6	·40	·26	·0106
12	6	·42	·24	·0095
13	3	·47	·23	·0097
14	8	·41	·20	·0064
15	3	·37	·18	·0046
18	8	·34	·30	·0120
19	3	·34	·33	·0145
20	3	·42	·30	·0148
22	6	·36	·32	·0145
24	2	·50	·32	·0101
30	3	1·00	·48	·0905
33	1	1·40	·45	·1113
40	2	1·65	·65	·2737
42	2	2·00	·68	·3632
45	3	1·70	·93	·5773
49	2	2·30	·68	·4176
51	2	2·10	·90	·6680
53	3	2·05	·72	·4173
55	2	2·30	·85	·6525
67	1	2·30	·90	·7316
71	2	2·95	·95	1·0454
75	2	4·00	·95	1·4175
87	2	2·30	·75	·5080
88	2	1·95	·85	·3726

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* The erroneous identification of this Holothurid with *Mülleria agassizii* Selenka was made, without reference to the taxonomic literature, from the label of a specimen in the biological museum of the Johns Hopkins University. Table I. in the present paper shows that three individuals were thus identified in the Harvard collections. Naturally such errors are due to the most superficial examination.

develops within the vitelline membrane. In the fourth day it has four tentacles and a budding posterior ventral pedicel (Edwards, 1907, pp. 775—776). In the sixth day after fertilization the embryo breaks its way through the slime covered egg membrane. The larval Holothurid has a primitive symmetry of five tentacles and one posterior ventral pedicel by means of which it creeps about. At times it is erect upon this posterior pedicel in a Hydra-like attitude. Then again it comes down on its tentacles while the pedicel is released from the bottom of the dish and waved aloft. It is nourished from the micro-organisms in the slime of the aquarium. This slime is left at each change of water so that the algae and other protists multiply and thus furnish a good supply of food.

Table VI. shows the growth in length*, diameter and volume of 89 of these very young individuals from the fifth, or last day within the vitelline membrane, to 88 days of age. In general there is a progressive increase in size up to 75 days. The diminution in volume of the individuals for 87 and 88 days undoubtedly indicates stunting from lack of food and other conditions in the small aquaria.

C. Colour.

a. LIVING AND ALCOHOLIC SPECIMENS.

On July 11, 1891, at Harbour Island, Bahamas, the colours of 25 living specimens were determined by comparison with Ridgway, 1886. Besides the usual colours shown in the following analyses of alcoholic specimens, coral-red, scarlet and scarlet-vermilion were each found in two individuals and flame-scarlet in one. These colours have disappeared from the specimens which have remained in alcohol. Ludwig, 1889–92, p. 27, points out that certain pigments like yellow, yellowish-red and red are changed by alcohol. However, in the Holothurids considered in this paper the masses of pigment are so thick that in most cases, excepting those noted above, the colours here recorded for the alcoholic specimens may be accepted as about the same as those of the living individuals. Since ordinarily, for taxonomy, museum rather than living examples are studied it is certainly important to have the colours properly taken and recorded from alcoholic specimens, if it is not possible at the same time to have them for comparison from the animals while alive.

b. METHODS OF DETERMINATION.

The colour was determined, on a clear day, with Ridgway, 1886, as the standard. In Tables VII. and VIII. a summary of the colouration and the distribution of the colours of the pedicels and papillae and the body is given for the bivium and trivium. The "stalk" is that portion of an appendage extending from the body-wall to within about ·5 mm. from the distal termination where usually the "end" is marked off by a ring around the tip. In the absence of the ring the "stalk" extends to the sucker. Sometimes, especially dorsally, the appendages arise from slight elevations, "warts," or in other cases from spots, or rings, differing in colour from the surrounding portions. For the body the mid-dorsal and lateral-dorsal regions correspond to the similar regions of the bivium. The trivium is often sharply marked off and occupies about two-fifths of the circumference of the animal. The mid-dorsal and lateral-dorsal regions are not always to be differentiated. Sometimes the differing lateral colour is along the dorsal edge of the side. "Dots" are minute bits of colour up to ·2 mm. diameter; "spots" are from ·2 mm. to 1 cm. in diameter, while "blotches" are larger areas often extending over a considerable portion of the surface. Light colour like cream is often due to heaps of spicules visible through the skin.

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* Measured from base of tentacles to proximal end of the posterior ventral pedicel.

The colouration is very variable as given in Table VII. and represented in Plate II. for the adult and in Plate I. for the young. The general statement of colouration is given in a brief and untechnical form by grouping the following

TABLE VII.

		AMBULACRAL APPENDAGES										BODY					
		Dorsal Stalks		Dorsal Ends		Ventral Stalks		Ventral Ends		Origin		Mid-Dorsal		Lateral-Dorsal		Ventral	
		Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%
Adult, 73 Specimens	Number of Colours	21	—	15	—	22	—	18	—	10	—	24	—	28	—	20	—
	Browns ...	67[a]	73·7	67[a]	92·0	38[b]	49·4	70[c]	91·0	11	58·0	90[d]	79·1	106[e]	72·1	56[f]	56·0
	Creams ...	11	12·1	5	6·9	8	10·4	4	5·2	1	5·3	10	8·7	24	16·4	34	34·0
	Grays ...	13	14·3	—	—	25	32·5	3	3·9	2	10·5	14	12·3	16	10·9	8	8·0
	Black ...	—	—	1	1·4	1	1·4	—	—	4	21·0	—	—	1	·7	1	1·0
	White ...	—	—	—	—	5	6·5	—	—	1	5·3	—	—	—	—	—	—
Young, 45 Specimens	Number of Colours	15	—	15	—	14	—	15	—	6	—	26	—	25	—	21	—
	Browns ...	40[g]	60·0	54[h]	81·7	27[g]	43·5	49[i]	89·0	5[j]	25·0	61[k]	38·7	65[l]	38·7	28	30·5
	Creams ...	19	28·4	6	9·0	19	30·7	5	9·1	1	5·0	28	17·9	34	20·3	27	29·1
	White ...	4	6·0	—	—	6	9·7	1	1·8	—	—	4	2·5	5	3·0	4	4·3
	Grays ...	3	4·5	6	9·1	9	14·5	—	—	1	5·0	63	40·0	61	36·5	32	34·5
	Black ...	1	1·5	—	—	1	1·6	—	—	13	65·0	1	·6	3	1·8	2	2·2

[a] Dark tints; seal, clove, predominant. [b] Tints, well distributed; seal, sepia and drab about alike. [c] Tints, distributed; seal, clove, sepia and clay-colour well marked. [d] Dark tints; seal, clove, Vandyke prominent. [e] Seal, clove, sepia, Prout's, Broccoli, drab and cinnamon prominent. [f] Tints well distributed; seal, clove, drab and cinnamon more pronounced. [g] Light tints; Prout's and clay-colour prominent. [h] Light tints; cinnamon and especially clay-colour prominent. [j] Seal, cinnamon and clay-colour. [k] Tints well distributed; seal, clove, sepia, Vandyke, Prout's, Isabella and clay-colour the more prominent. [l] Seal, clove, Prout's, Isabella and clay-colour prominent.

TABLE VIII.

Distribution of Colours on the Body expressed in Percentages.

		Whole Body Uniform	Mid-Dorsal			Lateral-Dorsal			Ventral		
			Uniform	Mixed		Uniform	Mixed		Uniform	Mixed	
				Ground	Markings		Ground	Markings		Ground	Markings
		12·3[a]	60·3[b]	—	—	28·8[c]	—	—	57·5[d]	—	—
Adult, 73 Specimens	Browns	—	—	77·7	53·8	—	81·0	50·0	—	53·1	57·1
	Creams	—	—	23·7	19·2	—	13·9	20·8	—	43·8	14·3
	Grays	—	—	3·6	26·9	—	3·8	29·2	—	3·1	28·6
	Black	—	—	—	—	—	1·3	—	—	—	—
		4·4[e]	—	—	—	6·6[f]	—	—	33·3[g]	—	—
Young, 45 Specimens	Browns	—	13·2	65·8	26·8	—	65·9	24·6	—	42·4	14·3
	Creams	—	—	18·4	28·1	—	20·5	30·4	—	36·3	32·1
	Grays	—	—	15·8	42·3	—	9·1	40·6	—	21·3	39·3
	Black	—	—	—	—	—	4·5	—	—	—	—
	White	—	—	—	2·8	—	—	4·4	—	—	14·3

[a] Mostly seal and clove-brown. [b] Mostly seal-brown. [c] Seal-brown, lighter browns and 1 cream-colour. [d] Lighter browns and creams. [e] Prout's brown and black. [f] Isabella-colour and cream. [g] Browns, creams, grays and 2 in black.

colours so that the 25 tints from seal-brown to clay-colour are the "*browns*," the 4 tints from cream-buff to cream-colour the "*creams*," and the 9 tints from slate-colour to pearl-gray the "*grays*," while black and white stand independently. *Browns:* seal, clove, sepia, chocolate, Vandyke, bistre, walnut, burnt umber, olive, mummy, Prout's, hair, Mars, raw umber, Broccoli, russet, tawny olive, drab, wood, cinnamon, écru drab, fawn-colour, Isabella-colour, ochraceous rufous, clay-colour. *Creams:* cream-buff, buff, buff-yellow, cream-colour. *Black.* *Grays:* slate-colour, slate-gray, gray, drab-gray, olive-gray, plumbeous, lilac-gray, lavender-gray, pearl-gray. *White.*

c. Colouration.

1. *Pedicels and Papillae.*

The dorsal stalks of the adult are chiefly dark brown while in the young the lighter browns prevail together with relatively more of the creams. In the ventral stalks of both adult and young the browns are less prominent than dorsally, and there is a marked increase in the grays and white. In the appendages all over the body the ends show a considerable increase in the browns over those characteristic for the stalks of the regions. In both adult and young the spots of origin are of a "dark" colour, either distinctly brown, or approaching black.

The colours of the tentacles have not been separately tabulated. Usually the ends (distal branches) are darker than the stalks and show the general colour of the body. The stalks are sometimes whitish, or colourless, or again, more or less of the darker tints of the ends run down upon them.

2. *Distribution of Colour on the Body.*

In Table VIII. it is shown that 12 °/₀ of the adult and only 4 °/₀ of the young are uniformly coloured. In all such cases browns and generally dark tints like seal and clove prevail. The mid-dorsal region is uniform in 60 °/₀ of the adult, and in only 13 °/₀ of the young. Here again are the browns exclusively. When the colours of this region are mixed the dark browns like seal, clove and Vandyke are predominant, with some intermixture of creams and grays, in both the ground-colour and the markings, of the adults. In the young, while the browns of lighter tints prevail in the ground-colour, the creams and especially the grays and white are in excess in the markings.

The lateral-dorsal regions present much more variegation, since only 28 °/₀ of the adult and 6 °/₀ of the young are uniform and there is a decided turning to the lighter browns and creams. When the colours are mixed the browns still predominate in the adult, although the markings are somewhat lighter, while in the young the ground-colour and markings are proportioned about as in the mid-dorsal with some increase of the creams.

The ventral region in the adult shows a return to greater uniformity (57·5 °/₀) but now the tints are among the lighter browns and the creams, while only 33 °/₀ of the young are uniform, with the browns, creams and grays about evenly represented. When the colours are mixed there is in the adult a decided increase of the creams in the ground-colour with more of the browns in the markings, while for the young in the ground-colour the creams, and especially the grays, increase, and in the markings the browns are equalled by white, each being only one-seventh, while the creams and grays make together five-sevenths, of the colouration.

In the adult the percentage of creams is doubled from mid- to lateral-dorsal and again from lateral-dorsal to ventral, thus gradually changing the colour from the dark brown back to the lighter belly, but even here the browns are predominant. In the young the increase in creams ventral is not so marked but, added to the very large percentage of grays over the whole body, gives the light and variegated colouration which so generally strikingly characterizes the young of *H. floridana* and may lead one upon superficial examination to class such individuals with *H. grisea* Selenka. Pourtalès, 1851, p. 13, noted that the young "are of a lighter colour than the old individuals." Hérouard, 1902, p. 8, describes the colour, at the moment of capture, of one specimen as greenish, dotted with brown spots upon the back, while the ventral surface is uniform, and he describes another as having, in addition to the brown dots, spots more extended and of a lighter brown. Clark, 1901, p. 258, notes great variation in colour.

In general in both adult and young, as graphically represented in Plates I. and

II. a, the ground-colour is marked with dots, spots, blotches, streaks, or more rarely rings, of different tints. Altogether the rings occur 37 times, 28 being in the browns and 9 in the creams. The party-coloured coats of these Holothurids are often very beautiful and sometimes present most fantastic combinations of nearly all the possible tints and shades of the browns, creams, and grays from black to white.

D. Tentacles and Ampullae.

Because of the great contraction of the anterior end of the body and of the retracted tentacles one is liable to make errors in counting tentacles even with the exercise of considerable care. After the first determinations, in working out the relation of these organs to the symmetry and the correlation of tentacles and ampullae, the various parts were spread out. In many cases a seeker was passed from ampulla to tentacle and in others Prussian blue was injected, either through the radial canal, or the ampulla. Thus, in several specimens, it was found that, in the previous count, short stumps of tentacles had been overlooked.

a. SYMMETRY IN ARRANGEMENT OF TENTACLES AND AMPULLAE.

Normally there are 20 tentacles arising from the radial canals and distributed evenly in the interradii as shown in Fig. A. See Plate V.

FIG. A, represents the scheme for the symmetry in the arrangement of the tentacles, tentacle ampullae, dorsal mesentery, and calcareous ring.

A dotted line indicates the median plane passing through the mid-ventral radius, the mid-dorsal interradius, and the attachment of the dorsal mesentery to the mid-dorsal interradiale. MVR, mid-ventral radius; RVR, right ventral radius; LVR, left ventral radius; RDR, right dorsal radius, LDR, left dorsal radius, *d*1, *d*2, the tentacles dorsal, and *v*1, *v*2, ventral, *r*1, *r*2 right, and *l*1, *l*2 left, of the radius marked; OC, oral canal; OE, oesophagus; RC, radial canal; T, tentacle; TC, tentacle canal; TA, tentacle ampulla; R, radiale; IR, interradiale.

Variations from the Symmetry of the Tentacles of the Mid-Dorsal Interradius in Relation to the Attachment of the Mesentery.

The simplest pattern in asymmetry is where the number of tentacles is normal, and among those for the dorsal interradius one more than usual is found on one side or the other of the mesentery. Including this kind of asymmetry found in individuals having at the same time more or less than the normal number of tentacles, there are, in all, 27 cases in which the tentacles of the dorsal interradius are distributed as follows:—

Number of Cases	To Right of Mesentery	To Left of Mesentery
12	3	1
8	1	3
1	3	2
4	1	2
1	4	1
1	1	4

The mesentery is attached at the junction of the dorsal interradiale with the left dorsal radiale in 10 cases (15, 28, 35, 41, 45, 66, 68, 70, 73, 89) and with the right dorsal radiale in 1 (98); to the left side of the dorsal interradiale in 33, 37, and to the right side in 34; slightly to the left of the mid-line in 19, 20, 77, and to the right of the mid-line in 113. The attachment is very broad for about 1 cm. in 40. In 37 the dorsal interradiale is fused with the right dorsal radiale. One would anticipate that the displacement of the tentacles should be in the opposite direction to the displacement of the mesentery found in 14 of the above cases. Such a relation indeed is present in 11 of the 14 specimens. While the mean, in adult and young, is about the same, there is greater range and greater variability in the adult than in the young.

b. NUMBER OF TENTACLES.

TABLE IX.

	Adult	Young
Number of Specimens ...	73	45
Mean	19·709 ± ·064	19·756 ± ·064
Standard Deviation ...	·808 ± ·045	·642 ± ·025
Coefficient of Variation ...	4·099 ± ·229	3·229 ± ·229
Range of Variation ...	16—22	18—21

Variation in the Number of Tentacles and the Relation of those Present to the Normal Symmetry.

Adult and young are tabulated separately but under this particular head they are treated as one group. Among the 30 varieties there is a decided tendency to reduction in the number of tentacles, since 23 individuals (76·6 °/ₒ) have less than the norm of 20 tentacles. It is well known that holothurians may lose one or more tentacles by accident, hence this excess in individuals with less than the norm probably represents such losses rather than congenital variation. This interpretation is also justified by the fact that in many cases of deficiency of tentacles the normal number, 20, of ampullae, is present.

Of the 12 cases in the 19 tentacle class, 9 (75 °/ₒ) have the tentacle absent in the trivium. Of the 10 cases in the 18 tentacle class, 3 lack the 2 tentacles in the trivium, 1 in the bivium, 4 lack 1 tentacle in each region and 2 are not determinable. Of the 23 cases in all, 15 (65 °/ₒ) have the tentacle deficiency in the trivium.

Holothurid 5 with 16 tentacles, lacks the 4 of the left ventral interradius, *v*2, *v*1 from the left ventral radius and *l*2, *l*1 from the mid-ventral radius. In the

TABLE X.

Variations with less than 20 Tentacles.

Distribution in accord with the scheme of symmetry given in Fig. A (Plate V.).
Absence of tentacles in particular radius indicated by 0.

Age	Serial Number	Right Dorsal				Left Dorsal				Right Ventral				Left Ventral				Mid-Ventral				Total Number
		d1	*d2*	*v2*	*v1*	*d1*	*d2*	*v2*	*v1*	*d1*	*d2*	*v2*	*v1*	*d1*	*d2*	*v2*	*v1*	*l1*	*l2*	*r2*	*r1*	
Adult	*1*	—	—	—	—	—	—	—	—	—	—	0	—	—	—	—	—	—	—	—	—	19
	35	—	—	—	—	—	—	—	—	—	0	—	—	—	—	—	—	—	—	—	—	19
	37	—	—	—	—	—	—	0	—	—	—	—	—	—	—	—	—	—	—	—	—	19
	41	—	—	—	—	—	—	—	—	—	—	—	—	—	0	—	—	—	—	—	—	19
	52	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0	—	—	—	—	—	19
	55	—	0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	19
	57	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0	—	—	—	—	—	19
	66	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0	—	—	—	—	—	19
	6	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	18*
	20	—	—	—	—	—	—	—	—	—	—	0	—	—	—	0	—	—	—	—	—	18
	28	—	—	—	—	—	—	0	—	—	0	—	—	—	—	—	—	—	—	—	—	18
	40	—	—	—	—	—	—	—	—	—	0	—	—	—	—	—	—	—	—	0	—	18
	45	—	—	—	—	—	—	0	—	—	—	—	—	—	—	—	—	—	0	—	—	18
	63	—	—	—	—	—	0	0	—	—	—	—	—	—	—	—	—	—	—	—	—	18
	5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0	0	0	0	—	—	16
Young	*88*	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0	—	—	19
	97	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0	—	—	19
	102	—	0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	19
	111	—	—	—	—	—	—	—	—	—	0	—	—	—	—	—	—	—	—	—	—	19
	77	—	0	—	—	—	—	—	—	—	—	—	—	—	—	0	—	—	—	—	—	18
	80	—	—	—	—	—	0	—	—	—	—	—	—	—	—	—	—	—	—	0	—	18
	82	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	18†
	89	—	—	—	—	—	—	—	—	—	0	—	—	—	—	0	—	—	—	—	—	18

* Tentacles lost before exact distribution was noted.

† Specimen very small and too mutilated for determination of distribution.

calcareous ring of this specimen (Fig. 96) the ventral and left ventral radialia are fused, the intervening left ventral interradiale being included in the composite piece.

TABLE XI.

Variations with more than 20 *Tentacles.*

Distribution in accord with the scheme of symmetry in Fig. A. Presence of extra tentacle in particular radius given.

Age	Serial Number	Right Dorsal	Left Dorsal	Right Ventral	Left Ventral	Mid-Ventral	Total Number
Adult	*30*	*d*3	—	—	—	—	21
	61	—	—	*d*3	—	—	21
	62	*d*3	—	—	—	—	21
	73	—	*v*3	—	—	—	21
	19	—	—	—	*d*3, *v*3	—	22
	34	—	—	*d*3	*v*3	—	22
Young	*113*	—	*d*3	—	—	—	21

In the 7 cases with more than the normal 20 tentacles there appears a slight tendency to the addition of extra tentacles dorsally.

c. BRANCHES ON TENTACLE AMPULLAE AND VARIATION IN THEIR NUMBER.

TABLE XII.

Branches on Tentacle Ampullae.

Distribution as in Fig. A. Number of branches in :—

Serial Number	Right Dorsal	Left Dorsal	Right Ventral	Left Ventral	Mid-Ventral	Total Number
1	—	*v*1 (2)	—	*v*1 (1)	—	3
2	—	*v*1 (1)	—	—	—	1
3	—	—	—	—	*l*1 (2)	2
7	*d*1 (7)	*d*1 (1) *v*2 (3) *v*1 (2)	—	*d*1 (7) *d*2 (3)	—	23
8	—	*v*2 (1)	—	—	—	1
10	*d*2 (1)	—	—	—	—	1
11	*d*2 (1)	—	—	—	—	1
15	*v*2 (1)	—	—	—	—	1
16	—	—	*d*2 (1)	—	—	1
30	—	—	—	—	*r*1 (1)	1
32	*v*1 (1)	—	—	—	—	1
33	—	*v*1 (1)	*v*1 (1)	—	—	2
35	—	—	*v*1 (2)	—	—	2
37	*d*1 (1)	—	—	—	—	1
63	*v*1 (1)	*d*2 (1)	—	—	—	2
67	—	*v*2 (1)	—	—	—	1
70	—	*v*1 (3)	—	—	—	3
73	—	*d*1 (1)	*d*1 (1)	—	—	2

In 18 individuals of Table XII. 27 of the tentacles have ampullae with branches. Of these, with origin as given in the Table, 18 have 1, 4 have 2, 3 have 3, and 2 have 7 branches.

In 16, *d*1 right dorsal radius arises under the mesentery, slightly toward the left and then passes over to the right. In 63, *d*1 right dorsal radius arises to the right of the mesentery and then passes beneath the mesentery to the left.

The ampullae of 7 are rather remarkable in having altogether 23 branches and in that 2 (*d*1, right dorsal radius and *d*1, left ventral radius) have each 7 branches in the form of a tuft. The branches are found only in adults and so indicate one of the changes which may come with advancing age.

d. VARIATION IN SIZE OF TENTACLES.

Variations from the normal size of the tentacle may be classed as *small* and *medium*. The number of small tentacles present in Holothurids of my series are found to vary from 2 in 42, 60, 93, 95, 96 and 3 in 18, 108 to 5 in 33 and 6 in 7. In addition to the 6 in the last case there are 4 tentacles of medium size. A stump of a tentacle, lost by accident, is present in 1, 56 and 58 and 2 such stumps in 42. In most cases it is probable that small and medium sizes are stages in regeneration from the stumps of those lost by accident although, of course, it is possible that they are congenital variations in size.

e. DEVELOPMENT OF TENTACLES.

The completed study of the development of the ambulacral appendages necessitates some minor changes from my preliminary report (1907). The first 4 tentacles are found on the 4th day, when the embryo is still within the vitelline membrane. Represented in accord with Fig. A, Pl. V. the 4 tentacles arise from the radial canals as follows:—*d*1, left dorsal; *d*1, right ventral; *r*1, mid-ventral and *d*1, left ventral. The 5th, *l*1, mid-ventral, buds on the 4th day and thus completes the primitive symmetry. The 6th, *d*2, right ventral, has developed by the 40th day. From the 40th to the 49th days appear the 7th, *d*2, left ventral, the 8th, *d*1, right dorsal and the 9th and 10th, *v*1, of either right, or left, dorsal. If the 9th arises from the right, then the 10th comes from the left, dorsal, or *vice versa*. The 11th, *r*2, mid-ventral, buds on the 49th day. The 12th, *l*2, mid-ventral, appears on the 71st day, and the 13th, the last in my series raised from the embryo, is *d*2, left dorsal, and is developed by the 75th day.

E. Pedicels and Papillae.

It is often very difficult to differentiate papillae from pedicels both as regards their form and the presence, or absence, of calcareous end-plates (cf. Ludwig, 1889–92, pp. 100—110; Lampert, 1889, p. 821 and 1896, p. 53). The whole matter is of such interest and importance in the solution of the problems presented by the thesis of this paper that I have taken up the various elements in detail.

TABLE XIII.

a. DISTRIBUTION PER SQ. CM.

Directly counted through an opening of 1 sq. cm. punched in a metal sheet. When the animal is sufficiently large an opening of 4 sq. cm. is used and the average sq. cm. obtained. On very small individuals the appendages are in distinct rows and an exact average per sq. cm. is impossible but the nearest number is given, although often obtained from a fraction of one sq. cm. and multiplied to the standard for comparison. In one case, 104, the smallest young individual, this leads to an error, for it is credited with 44 dorsal appendages per sq. cm., when a count shows only 12 present in the dorsal region.

	DORSAL		VENTRAL	
	Adult	Young	Adult	Young
Number of Specimens ...	73	45	73	45
Mean	13·096 ± ·279	20·667 ± ·876	25·288 ± ·675	35·112 ± 1·432
Standard Deviation ...	3·545 ± ·197	8·717 ± ·620	8·550 ± ·477	20·147 ± 1·432
Coefficient of Variation ...	26·994 ± 1·507	42·175 ± 3·000	33·819 ± 1·867	57·379 ± 4·179
Range of Variation ...	6—22	8—44	6—50	11—128

The above table shows that there are 1·6 as many appendages in the trivium as in the bivium in the adult, and 1·4 as many in the young, and that the young have a considerably greater standard deviation in both regions. There is a wide range of variation in the adult as well as in the young, and thus in some individuals the appendages are scattered while in others they are closely crowded. The number per sq. cm. may vary more or less with the state of contraction of the specimens. The absolute number for the whole body in very small individuals is much less than in large ones, yet the number per sq. cm. may be relatively very large as in 77 which is 4·4 cm. long and has 128 ventral appendages per sq. cm. while the largest number found in any adult is 50 per sq. cm. in 23, which is 12 cm. long. Ordinarily the smaller number of appendages per sq. cm. in the adult demonstrates that the increase in number of appendages does not keep pace with the general growth of the body-wall.

In 5 specimens the papillae, as defined on p. 267, were counted, yielding an average of ·86 per sq. cm. *In other words about* 1 *out of* 16 *of the dorsal appendages is a papilla.*

b. DEVELOPMENT AND APPEARANCE.

The first pedicel is present as a bud from the posterior end of the mid-ventral radius of the 4th day embryo. The 2nd buds on the 7th day, the 3rd, on the

22nd day, and the 4th on the 33rd day, all 3 from, and *to the left of*, the mid-ventral radius. On the 24th day the 1st pair of papillae bud ventral from the anterior ends of the dorsal radii and will become the first of the *warts* described below. On the 30th day the first pair of pedicels appear from the lateral-ventral radial canals, one on each side. Not before the 40th day does there appear a pedicel from the mid-ventral radius *to the right.* Gradually the number of ambulacral appendages increases until on the 75th day there are 30 developed pedicels and papillae and 68 buds, mostly arranged in rows along the radial canals.

In the adult this arrangement in radial rows is obscured by the presence of fairly evenly distributed interradial appendages. The smaller young individuals, as Pourtalés, 1851, p. 12, remarks, show the radial rows more distinctly. In 3 of the smallest of the young of my statistical series the appendages were counted with the following result:—

Serial Number	Volume c.c.	Mid-Ventral Radius	Right Ventral Radius	Left Ventral Radius	Right Dorsal Radius	Left Dorsal Radius	Inter-radial in Dorsal Region	Totals
104	·26	22	21	22	6	6	—	77
103	·46	23	23	22	10	9	12	99
105	1·00	30	30	30	12	12	36	150

c. WARTS.

Pourtalés, 1851, p. 12, noted that of the dorsal papillae the two rows situated near to the ventral surface, are always very conspicuous. "They are erectile, like the suckers, and possess a canal, which communicates with an internal vesicle." I have adopted the name *warts* for the more or less prominent conical projections usually formed from an accumulation of rosettes, perforated plates and their developmental stages. The warts nearly always bear a papilla; occasionally more than one. They appear along the sides, having arisen from the right and left dorsal radii or sometimes they are scattered over the back. Being made of spicules, the warts are of light colour and generally stand out against the darker background. Where warts are not noted it is probable that some are present but obscured by an increased number of spicules in the skin, or by dark colour.

TABLE XIV.

1. *Distribution of Warts.*

	Right and Left	Right Only	Left Only	Scattered on Bivium	Traces	None	Totals
Adult ...	20	—	—	1	25	27	73
Young ...	35	1	2	1	5	1	45

These warts are much more prominent in the young for $97\frac{7}{9}\ ^{\circ}/_{\circ}$ of this class show warts or their traces, as against 63 $^{\circ}/_{\circ}$ of the adult. Of those with warts, 80 $^{\circ}/_{\circ}$ of the young have them in the prominent right and left lateral rows, while this is true in only 27 $^{\circ}/_{\circ}$ of the adult.

TABLE XV.

2. *Number of Warts on Sides of Bivium.*

	ADULT		YOUNG	
	Right	Left	Right	Left
Mean	9·25	8·65	7·90	7·68
Range of Variation ...	5—15	5—19	1—14	3—12

d. PAPILLAE AROUND THE ANUS.

Selenka, 1867, p. 325, mentioned a crown of papillae surrounding the anus, and Théel, 1886, p. 216, described a specimen of *H. mexicana* Ludwig, as having the "anus with five minute groups of papillae."

TABLE XVI.

Distribution of Papillae around the Anus.

Age	In Groups							In a Circle	Indefinite	Destroyed	Totals
	Number of Groups										
	0	*1*	*2*	*3*	*4*	*5*	*6*				
Adult ...	1	0	1	1	8	44	1	4	12	1	73
Young ...	1	0	0	1	4	31	1	7	—	—	45

From Table XVI. it is seen that in 60·4 $^{\circ}/_{\circ}$ of the adult and 68·8 $^{\circ}/_{\circ}$ of the young there are 5 groups of papillae around the anus. These groups may run into one another but their centres are always clearly marked. The anal papillae vary in length from ·1 to 1·5 mm. and have the supporting rods characteristic of papillae in general.

F. Thickness of Body-wall.

The much larger mean and range of the adult show, as one would naturally expect, that the body-wall (skin) becomes thicker with age. Not only is the adult body-wall nearly three times as thick as the young, but at the same time the standard deviation is nearly three times as much.

TABLE XVII.

Determined by measuring in mm. the thickest and thinnest places along a ventral incision and then taking the average.

	Adult	Young
Number of Specimens ...	62	44
Mean	4·144 ± ·195	1·495 ± ·084
Standard Deviation ...	2·274 ± ·138	·827 ± ·059
Coefficient of Variation ...	54·876 ± ·332	5·527 ± ·397
Range of Variation ...	1·0—13·0	·1—3·0

Naturally some individuals will die with the body-wall much more contracted than the average, and others with it much more expanded. Thus in 56 the body-wall is quite uniformly "thin" (·3 mm.—1·0 mm. thick) and in this one character the specimen is similar to *H. atra*.

G. Calcareous Spicules of the Body-wall.

These spicules are of three classes; tables, rosettes and perforated plates. They are not always distributed evenly throughout the body-wall but often in heaps and groups, which in some cases may be due to greater contraction in the regions where they occur. In general the spicules are more numerous in the trivium. At least in the young the spicules are being developed constantly, so that a more or less complete series of stages illustrating their development may be secured. The data were obtained from pieces of the body-wall of 2 or 3 sq. cm. area taken from near the middle of the body, cleared in dilute potassium hydras and then, after dehydration by the alcohols, mounted from cedar oil into balsam.

a. TABLES.

The tables in *H. floridana* are like those of *H. atra* and so in the following general description of their development, structure and variation no attempt is made to keep separate account of *H. floridana* and *H. atra* specimens. The tables studied did not lie near any appendage and so unquestionably belong to the body-wall. They are found in the superficial layer of the dermis.

1. *Development of the Table.*

The developmental series represented by Pl. IV., Figs. 42—49, was selected from many individuals during the progress of this study. As shown by Düben and Koren, 1844, this spicule begins as a cross-shaped body or as better expressed by Ludwig, 1889–92, pp. 45, 56, as a short rod with forked ends (Fig. 42). At the proximal end of each prong a vertical rod arises (Figs. 43, 44). The end of each prong forks (Fig. 45, a variate with 5 prongs and 5 vertical rods), and these branches grow toward one another while the vertical rods rise higher and the centre of the fundamental rod becomes elevated (Fig. 46). The outer branches grow together and unite to form the primary and peripheral holes of the disc, while the distal ends of the vertical rods are joined by transverse beams to build the crown, and then the teeth begin to appear (Fig. 47). Finally the last cross-beam is added to complete the crown and spire, the last peripheral branches fuse to form the disc, the teeth enlarge and the normal table is completed (Figs. 48, 49).

2. *Structure of the Table.*

The typical table consists of a disc perforated by 4 larger, primary holes extending toward the centre alternating with 4 secondary holes of medium size in the periphery (Figs. 49, 64—97). Generally there are one or more (range 1—9) smaller tertiary holes in between the secondary and forming with them a peripheral circle (Figs. 57—62). The bars between the primary holes bend upward, so that the centre of the disc is elevated, and at the same time it supports a spire consisting of 4 vertical rods united distally by cross-beams to form a crown (Fig. 49). The crown bears at each of its 4 corners, 3 teeth; 2 horizontal, diverging at right angles, each continuing the axis of a cross-beam, and the 3rd perpendicular to the plane of the others (Fig. 75, the positions of the underlying vertical rods shown by dotted circles).

3. *Variation in Crown and Vertical Rods.*

Among the 234 tables of *H. floridana* 5 have a triangular crown (Fig. 79) supported by 3 vertical rods; 5 have the crown arrested in development, the central hole not formed and with only 3 vertical rods (Fig. 80), and 4 have the normal 4 vertical rods but with the crown incomplete on one side. Three have spires with 5 vertical rods.

The number of teeth varies from 6 to 16, the largest number being represented in Fig. 78. Sometimes odd teeth project from the middle of the cross-bars (Figs. 76, 77, 83). There are 5 crowns in each of which 1 tooth is bifid at the tip; 2 crowns with 2 teeth bifid; 1 crown with 6 teeth bifid; 1 crown with 7 teeth bifid and 1 crown with 1 tooth trifid.

Not included in the statistical series of *H. floridana* are several interesting variations. Fig. 81 shows a triangular crown without a central hole; Fig. 82, a partly formed crown hole; Fig. 86, an incomplete crown with 3 teeth bifid and 5 supporting rods; Fig. 87, a complete disc with 5 rods and no crown; Fig. 88, the disc, and Fig. 89, the crown, of a table with 7 rods; Fig. 90, from above and Fig. 91 from below, a depressed abnormal form.

b. TABLES OF BIVIUM AND TRIVIUM IN *H. FLORIDANA*.

For the study of these tables data were taken from 14 Holothurids representing various places scattered over the Florida-Caribbean region. When possible the measurements and counts were made from 10 tables in the bivium and 10 in the trivium of each specimen. Without attempting a study of the variation in the different parts of the table in individual Holothurids, the determinations for the species were made from the whole 130 dorsal and 104 ventral tables.

TABLE XVIII.

Tables of Bivium and Trivium.

		Disc				Crown			
		Number of Peripheral Holes	Number of Spines	Diameter μ	Height μ	Number of Teeth	Diameter of Hole μ	Diameter not including Teeth μ	Diameter including Teeth μ
Dorsal	Mean	5·746 ± ·149	·907 ± ·091	50·210 ± ·351	54·150 ± ·529	12·177 ± ·064	7·220 ± ·140	18·720 ± ·150	38·590 ± ·106
	Standard Deviation	2·523 ± ·106	1·883 ± ·079	5·940 ± ·248	8·945 ± ·374	1·078 ± ·045	2·340 ± ·088	2·534 ± ·158	5·176 ± ·217
	Coefficient of Variation	43·909 ±1·837	199·21 ± ·833	11·839 ± ·490	16·510 ± ·690	8·849 ± ·370	32·41 ±1·36	13·510 ± ·570	13·420 ± ·570
	Range of Variation	0—13	0—10	35·2—67·2	32·3—72·6	8—16	3·2—12·8	12·8—22·4	25·6—54·4
Ventral	Mean	4·654 ± ·144	·346 ± ·075	42·539 ± ·524	45·610 ± ·660	11·692 ± ·092	6·560 ± ·013	18·750 ± ·241	35·904 ± ·388
	Standard Deviation	2·170 ± ·091	1·150 ± ·044	5·342 ± ·140	9·934 ± ·465	1·394 ± ·065	1·920 ± ·092	2·400 ± ·115	6·012 ± ·281
	Coefficient of Variation	46·617 ±2·180	332·29 ±1·554	12·550 ± ·590	21·770 ±1·020	11·923 ± ·558	29·260 ±1·400	12·800 ± ·610	16·740 ± ·780
	Range of Variation	0—10	1—6	32·0—57·6	24·3—81·0	6—14	0—9·6	9·6—22·4	22·4—51·2

1. *Disc.*

The form of the disc has the following distributions: *dorsal*;—square, 81 (62·3 $^{\circ}/_{\circ}$) (Pl. IV. Figs. 54 and 66); irregularly square, 8 (6·2 $^{\circ}/_{\circ}$) (Figs. 53 and 73); round, 7 (5·4 $^{\circ}/_{\circ}$) (Figs. 60 and 72); irregularly round, 12 (9·2 $^{\circ}/_{\circ}$) (Figs. 62 and 74); irregular, 22 (16·9 $^{\circ}/_{\circ}$) (Figs. 52, 55 and 70): *ventral*;—square, 58 (55·8 $^{\circ}/_{\circ}$); irregularly square, 14 (13·5 $^{\circ}/_{\circ}$); round, 3 (2·8 $^{\circ}/_{\circ}$); irregularly round, 13 (12·5 $^{\circ}/_{\circ}$); irregular, 16 (15·3 $^{\circ}/_{\circ}$). These types run into one another, and when the irregular variations are added to their respective types the form of the disc is practically the same in both bivium and trivium.

The mean number of peripheral holes in the disc, in the dorsal tables, is 6*, with a range of 0—13; in the ventral, 5 with a range of 0—10 (Figs. 49—74). In the series of variates there is a typically symmetrical form with 4 secondary holes (Figs. 54, 64—67), one at the base of each vertical rod (Fig. 49). When more than the 4 secondary peripheral holes are present, the additional tertiary ones are usually smaller (Fig. 61). It is to be noted that an asymmetrical distribution of peripheral holes prevails.

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* In the discussion of the tables the nearest whole numbers are used.

The mean number of spines on the disc is ·9 in the dorsal tables with a range of 0—10 and ·3 in the ventral, with a range of 0—6. With the mean less than 1 it is apparent that spines are not often found in any number. Sometimes the spines are large (Fig. 69), and again they may arise from a projection of some size (Fig. 68). Of the dorsal tables 22 °/₀ bear spines while only 11 °/₀ of the ventral are so characterized, and thus the possession of spines cannot be considered normal in the species. Hence, as a diagnostic character of Semper's discarded variety *amboinensis*, the possession of spines on the disc has no significance.

The mean diameter of the disc is 50 μ in the dorsal tables, with a range of 35 μ—67 μ, and 43 μ in the ventral, with a range of 32 μ—58 μ.

2. *Height.*

The dorsal tables have a mean height of 54 μ, with a range of 32 μ—72 μ; the ventral 45 μ, with a range of 24 μ—81 μ, and thus the dorsal tables are 20 °/₀ higher than the ventral.

3. *Crown.*

The mean number of teeth is 12 in the dorsal tables, with a range of 8—16, and 12 in the ventral, with a range of 6—14.

The mean diameter of the hole is 7 μ in the dorsal crowns, with a range of 3 μ—13 μ; 7 μ in the ventral, with a range of 0 μ—10 μ. In Fig. 76 this hole is large; in Fig. 79, small, while in some cases it is absent (Fig. 81).

The mean diameter of the crown, not including teeth, is 19 μ in the dorsal tables, with a range of 13 μ—22 μ; 19 μ in the ventral, with a range of 10 μ—22 μ; the diameter of the crown including teeth 39 μ in the dorsal tables with a range of 26 μ—54 μ; 36 μ in the ventral, with a range of 22 μ—51 μ. Taking one half of the difference between the two last determinations, the average length of the teeth on the crown is 10 μ in the bivium and 9 μ in the trivium.

Thus from an examination of Table XVIII. it is found that the dorsal tables have more peripheral holes, spines and teeth, broader crown, larger crown-hole and longer teeth than the ventral tables, albeit the difference in some of these characters is very small. As shown by the standard deviations, the features of the disc are more variable in the dorsal tables, while the height and crown characters are more variable in the ventral tables.

In the suckers of the dorsal pedicels are found what may be called reduced tables, in which only that central part of the disc immediately below and supporting the well-developed spire is present (Fig. 92).

c. ROSETTES AND ROSETTES WITH HOLES.

Generally the rosettes are stellate of 3 or 4 broad rays, forked and rounded at the swollen ends (Figs. 29—31). Sometimes the central part is drawn out so that the spicule is irregularly H-shaped (Fig. 28), and then from this central bar additional projection may arise (Fig. 32). When some of the prongs of the forked ends grow together and fuse, the spicule comes under the class of rosettes with holes (Fig. 33). The average thickness of the rosette is 5 μ but often the centre is still thicker (10 μ), giving a biconvex contour to the spicule as seen in profile. These spicules lie in the dermis below the tables. They may be few and scattered but are, for the most part, densely crowded together in heaps, often of irregular outline, or less frequently in rings.

The determinations recorded in Table XIX. were taken from 10 specimens of *H. floridana*, 15 spicules from the dorsal region and 15 from the ventral, of each Holothurid, or from a total frequency of 150 dorsal and 150 ventral rosettes and rosettes with holes.

In the bivium there are 141 (94 °/₀) rosettes and 9 (6 °/₀) rosettes with holes, and in the trivium 133 (89 °/₀) rosettes and 17 (11 °/₀) rosettes with holes.

TABLE XIX.

Rosettes and Rosettes with Holes.

		ROSETTES		ROSETTES WITH HOLES		
		Greater Diameter μ	Smaller Diameter μ	Number of Holes	Greater Diameter μ	Smaller Diameter μ
Dorsal	Mean	22·030	18·090	2·556	26·800	21·470
		± ·221	± ·173	± ·321	± ·509	± ·449
	Standard Deviation ...	3·903	3·056	1·427	2·265	1·996
		± ·157	± ·123	± ·228	± ·356	± ·317
	Coefficient of Variation	17·700	16·910	55·829	8·430	9·320
		± ·710	± ·680	± 8·876	± 1·340	± 1·480
	Range of Variation ...	14·4—28·8	9·6—24·0	1—5	24·0—28·8	19·2—24·0
Ventral	Mean	20·470	17·010	3·353	27·450	21·530
		± ·223	± ·161	± ·258	± ·768	± ·506
	Standard Deviation ...	3·814	2·748	1·577	4·693	3·093
		± ·158	± ·114	± ·183	± ·543	± ·358
	Coefficient of Variation	18·610	16·110	47·037	17·080	14·350
		± ·770	± ·670	± 5·441	± 1·970	± 1·660
	Range of Variation ...	9·6—28·8	9·6—24·0	1—6	19·2—33·6	14·4—24·0

In the bivium the mean dimensions of the rosettes are 22 μ × 18 μ and of the rosettes with holes, 27 μ × 21 μ; in the trivium the rosettes are 20 μ × 17 μ and the rosettes with holes, 27μ × 22μ. The increased size of the rosettes with holes shows that they are older, and it is probable that most of them are developmental stages of the perforated plates.

Comparing the rosettes in the bivium and trivium, it is seen that the mean number of holes in the former is less than 3 and in the latter more than 3. Corresponding to this increase in the mean number of holes, the greater diameter of the ventral rosettes with holes is 16 °/₀ above that of the dorsal, while at the same time the standard deviations show that the size of these ventral rosettes is more variable and they have a greater range. Pourtalès, 1851, referred to the rosettes when he noted (p. 12) that "the skin contains small, calcareous bodies, of various forms, but mostly in that of an irregular cross, or star, the branches of which are bifurcated at their extremity."

d. PERFORATED PLATES.

The determinations in Table XX. were made from 10 Holothurids, taking 15 plates in the bivium and 15 in the trivium of each, thus giving a total frequency of 150 dorsal and 150 ventral plates. In general the plates are more numerous ventrally than dorsally.

TABLE XX.

Perforated Plates.

		DORSAL			VENTRAL		
		Number of Holes	Length μ	Width μ	Number of Holes	Length μ	Width μ
Developmental Stages	Mean	6·420 ± ·128	28·840 ± ·204	22·870 ± ·262	6·515 ± ·181	26·510 ± ·445	21·130 ± ·314
	Standard Deviation ...	1·539 ± ·090	2·461 ± ·144	3·155 ± ·190	1·540 ± ·128	3·787 ± ·314	2·673 ± ·222
	Coefficient of Variation	23·793 ± 1·397	8·530 ± ·506	13·810 ± ·810	23·634 ± 1·962	14·290 ± 1·190	12·630 ± 1·050
	Range of Variation ...	2—8	19·2—38·4	14·4 –28·8	4—8	19·2—33·6	14·4—24·0
Developed	Mean	13·476 ± ·216	29·040 ± ·207	23·710 ± ·192	14·761 ± ·244	26·690 ± ·212	22·460 ± ·170
	Standard Deviation ...	2·932 ± ·153	2·819 ± ·147	2·603 ± ·140	3·915 ± ·173	3·402 ± ·151	2·723 ± ·120
	Coefficient of Variation	21·754 ± 1·132	9·710 ± ·513	10·960 ± ·566	26·523 ± 1·170	12·730 ± ·560	12·110 ± ·530
	Range of Variation ...	9—21	24·0—38·4	19·2—28·8	9—31	19·2—38·4	19·2—33·6

1. *Development of the Perforated Plate.*

The plate begins as a rod with forked ends, the simple rosette, like Pl. IV. Fig. 28, of the same fundamental form (cf. Ludwig, 1889–92, p. 58) as the 'Anlage' of the table (Fig. 42) but with the central rod shorter and more slender and the prongs shorter, wider and thicker. The diverging branches of the prongs unite to form holes and thus is developed the 4-holed symmetrical *Type a* (Fig. 37) in which the 2 central holes are about twice the size of the 2 terminal holes. Of this type there are 2 °/₀ dorsally and 6 °/₀ ventrally. Plates of this stage in general have not the perfectly smooth contour of Fig. 37 but show one or more bifurcating branches which will unite to make 2 additional holes at each end and thus produce the 8-holed symmetrical *Type b* (Fig. 38). Eighteen per cent. of both the dorsal and ventral developmental stages are of *Type b*. The majority of *Type b* plates have the peripheral prongs indicating growth toward the complete plate, and also bars running into the larger central holes, as well as occasionally into the smaller holes (Fig. 38 a).

*Type a** with 4 holes asymmetrically distributed does not occur in the dorsal series but does in 6 °/₀ of the ventral, and *Type b** with 8 holes asymmetrically distributed is found in 5 °/₀ of the dorsal and 15 °/₀ of the ventral. *Type c* includes all of the plates with 5—8 holes indefinitely distributed, part of them showing the regular contour which might be taken to indicate a fully developed plate, and part of them with the prongs of growth of an incomplete plate. *Type c* constitutes 76 °/₀ of the dorsal and 55 °/₀ of the ventral plates. It is quite possible that many of these types, especially those with regular contours and of large size, are developed plates ("buttons"), but since *Types a* and *b* are clearly two well-marked developmental stages, I have included all plates with 8 or less holes in the same general group of perforated plates in the process of development. Their mean number of holes is about 6·5 both dorsally and ventrally, their mean dimensions $29\mu \times 23\mu$ dorsally and $27\mu \times 21\mu$ ventrally with practically no difference in the standard deviations in the two regions.

2. *Structure and Variation of the Developed Perforated Plates.*

The plate becomes developed by the addition of more holes to *Type b*, while, with increasing age all of the holes may be gradually filled in with lime (Figs. 39, 40, 41). The mean number of holes is 13 dorsally and 15 ventrally and the mean dimensions $29\mu \times 24\mu$ dorsally and $27\mu \times 22\mu$ ventrally, with the standard deviations somewhat greater in the ventral region.

20 °/₀ of the dorsal and 10 °/₀ of the ventral plates have the peripheral projections which indicate that additional holes may be in process of formation. Such a plate, much larger than the average, is shown in Fig. 34. In many cases a bar, or sometimes 2 or 3 may grow out into each of the 2 primary central holes (Fig. 34). The bar may grow through the hole, fusing with the opposite wall, and thus forming 2 holes in place of the normal single hole.

In the majority of these developed plates it is easy to trace the fundamental *Type b* (cf. Pl. VIII. Fig. 7, d, e of *H. africana* Théel, 1886).

Sometimes the initial forked bar is much thicker than usual (Fig. 35) and after the fusion of the terminal branches the 2 primary holes formed are very small (Fig. 36). With age the holes may become so much filled in with calcareous matter as to assume the form of pits (Fig. 41, where 11 of the 15 holes have become pits; indicated by the cross lines). Upon some of the plates are ridges and then the holes lie in the furrows between the ridges. The standard deviations given in Table XX. show that the developed plates are more variable than the undeveloped.

A specimen from Key West, Florida, compared with specimens from Porto Rico and St Thomas, presents plates with more holes and at the same time has more plates with developmental branches which indicate that yet additional holes will be formed. An extended study of the perforated plates from the various localities would, without doubt, reveal interesting place modes.

Théel, 1886, p. 215 (cf. also Clark, 1901, p. 258) in describing *H. mexicana* notes that "of the crowded plates two types may be observed, one more rounded, pierced with minute and commonly more numerous holes; and the other irregularly rectangular, with fewer and larger holes." The first of the two types of these authors I consider identical with the developed plate, and the second with the developmental stage *Type b* described in this paper. Ludwig, 1874, in his original description of *H. mexicana* only mentions "numerous symmetrical perforated plates" but figures the two kinds (Taf. VII. Fig. 47 a). These facts, together with the other points in agreement, establish my claim that *H. mexicana* Ludwig and *H. africana* Théel are identical with *H. floridana* Pourtalès, and therefore synonymous with the last-named species.

e. NUMBER OF ROSETTES AND PERFORATED PLATES.

In a piece of the body-wall of 1 sq. cm. area, the average thickness of the layer of spicules, extending through about $\frac{1}{7}$ of the body-wall, was ·82 mm. The spicules averaged ·04 mm. long × ·036 mm. wide × ·005 mm. thick, giving a possible 145,000 spicules in 1 cu.mm., or 11,890,000 to 82 cu.mm., or 1 sq.cm. of surface. The spicules are packed densely in this layer, but a discount must be made for gaps as well as protoplasmic structures between the spicules. Even allowing this to be 50°/₀ there would be still over 5,000,000 spicules to a sq.cm. of surface in the crowded areas.

f. CORRELATION OF ROSETTES AND PERFORATED PLATES WITH ADVANCING AGE.

In order to determine whether the different classes of spicules are correlated with special ages of the Holothurid, 62 from the whole series of 118 specimens were carefully examined without, however, any attempt at a quantitative determination. Hence the percentages given below are only approximate. A specimen usually shows a large majority of either rosettes or perforated plates but, at the same time, in each individual some examples, at least, of all classes of spicules occur, illustrating more or less completely the developmental series from the simple rod and x-formed rosette to the complete perforated plate.

The rosettes are specially abundant and thus characterize specimens 18, 26, 42, 47, 52, 53, 71, 75, 78, 80—86, 93, 95, 106, 113—118, twenty-five in all, of which eighteen, or 72 °/₀, are young as judged by the criterion of size (cf. pp. 239, 243). But of the other seven, four do not much exceed the limit for the young (50 c.c.) and the remaining three are considerably below 209·58 c.c., the average size of the adult. Allowing for a natural variation in which some young are larger than the limit I have assumed, it may be asserted that, for the most part, the rosettes are characteristic of young specimens. The perforated plates characterize 25 specimens, 15, 19, 21—25, 36—38, 51, 54, 55, 57—67, 72, all of which are adult. So without question the perforated plates are characteristic of the adult. Four fully grown specimens 32, 50, 56, 69, have 90 °/₀ perforated plates and 10 °/₀ developmental stages, thus closely approaching the adult state. Holothurid 17, with 90 °/₀ developmental stages and 10 °/₀ perforated plates, and 30, 31, 33, with 90 °/₀ developmental stages and 10 °/₀ rosettes, present such intermediate conditions as would be expected in occasional individuals. Specimens 44, 76, 79, 94, have 90 °/₀ rosettes and 10 °/₀ developmental stages, thus mostly presenting a young condition. Of these four, 44, an adult, has a volume much less than the adult average, while the other three are young but above the average for the young. *In view of these facts it is clear that the large majority of spicules in the young are rosettes and in the adult, perforated plates*, while a number of specimens give the intermediate stages of the developmental series. Some rosettes and developmental stages may be found in any adult and some perforated plates in any young.

Mitsukuri, 1897, discovered that, in *Stichopus japonicus* Selenka, with advancing age the tables gradually degenerate "until in full-grown individuals, there are found nothing but small perforated plates, representing only a small central part of the basal disc and without any trace of the spire." In *H. floridana* I have found correlated with advancing age a succession in the developmental stages of the perforated plate, but not a series of degenerative changes in the tables.

H. Calcareous Spicules of the Ambulacral Appendages and the Differentiation of Pedicels and Papillae.

The differentiation of pedicels and papillae is of primary importance. An exact definition of each of these two classes of ambulacral appendages is much needed. In such definitions the elements to be especially considered are (*a*) Form, (*b*) Suckers, (*c*) End-plates, and (*d*) Supporting Rods, together with the correlation of these elements. The end-plates and supporting rods are additional to the tables, rosettes and perforated plates described above for the body-wall, and found as well in the walls of the pedicels and papillae which are evaginations of the body-wall.

From 9 holothurids 88 dorsal ambulacral appendages were taken, and from 3 other specimens, 50 ventral appendages. In a number of cases certain elements were not sufficiently clearly seen for accurate judgment and so are called "not determinable."

a. FORM.

The typical pedicel is cylindrical (Pl. III. Fig. 2), and the papilla conical (Fig. 1). In this species the form of the 88 appendages of the bivium studied is: cylindrical, 49 (55·7 °/o); conical, 4 (4·5 °/o); not determinable, 35 (39·8 °/o). In the trivium all are cylindrical.

b. SUCKERS.

The presence of a fundamental sucker is the chief and necessary character of the pedicel. In 73 (83 °/o) of the dorsal appendages the sucker is present, in 2 (2·3 °/o) rudimentary, in 4 (4·5 °/o) absent and in 9 (10·2 °/o) not determinable. In all of the ventral appendages a well-developed sucker is present.

c. END-PLATES.

With but one exception the ambulacral appendage has at least some trace of a perforated plate, or a rosette, as the end-plate. One dorsal case was not determinable. In the pedicel the end-plate is large and located in the base of the sucker (seen in profile in Plate II. Fig. 2).

TABLE XXI.

Diameter of End-plates in μ.

	DORSAL				VENTRAL		
	Type				Type		
	A	*B*	*C*	*D*	*A*	*B*	*C*
Frequency	41 (47·7 °/o)	36 (41·9 °/o)	8 (9·3 °/o)	1 (1·1 °/o)	46 (92 °/o)	3 (6 °/o)	1 (2 °/o)
Mean	540·953	354·677	182·380	90·000	701·260	288·000	210·000
	±9·632	±5·676	±5·195	—	±13·785	±9·927	
Standard Deviation ...	91·436	50·486	21·786	—	138·545	25·493	
	±6·811	±4·013	±3·674	—	± 9·743	±7·020	
Coefficient of Variation	16·900	14·230	11·940	—	19·750	8·850	
	±1·270	±1·130	±2·020	—	± 1·380	±2·430	
Range of Variation ...	435—750	225—420	120—195	—	450—975	255—315	

The most completely developed end-plate I have called *Type A*. It is nearly circular and has numerous holes varying in size (Fig. 3). In some cases the holes are less uniform with larger holes toward the centre (Fig. 4). *Type A* has a mean diameter of 541 μ with a range of 435 μ—750 μ dorsally. In the trivium *Type A* is larger, having a mean diameter of 701 μ with a range of 450 μ—975 μ. This type occurs in 48 °/o of the dorsal appendages and in 92 °/o of the ventral.

Type B (Fig. 5) has a mean diameter of 355 μ with a range of 225 μ—420 μ dorsally and therefore it is something over half the size of *Type A* in this region. In the trivium *Type B* has a mean diameter of 288 μ with a range of 255 μ—315 μ. *Type B* occurs in 42 °/₀ of the dorsal appendages and in only 6 °/₀ of the ventral.

Type C, with the smaller holes toward the centre (Fig. 6), or with larger, irregular holes (Fig. 7), in the bivium, has a mean diameter of 182 μ with a range of 120 μ—195 μ, and in the trivium occurs but once with a diameter of 210 μ.

The most degenerate form in this species is *Type D* (Fig. 8) with a diameter of 90 μ. It only occurs once dorsally and not at all ventrally.

d. SUPPORTING RODS.

1. *Dorsal.*

In the dorsal appendages supporting rods are present in 14 (15·9 °/₀), absent in 44 (50 °/₀) and not determinable in 30 (34·1 °/₀). Those especially characteristic of the papillae (Figs. 10, 11, 12) form a series of rib-like structures, from rods only very slightly curved and with a few spines at each end (Fig. 10) to those more bowed and spinous with the ends slightly branched (Fig. 11). Occasionally a rod is found either straight, or curved, with the ends expanded and from 1 to several holes in addition to the spines and branches. Fig. 13 presents a rare variate in the form of a rosette with a few large holes. The tentacles have supporting rods similar to the series described above for the papillae. In the tentacles the rods are confined to the branched ends and are not found in the stalks.

2. *Ventral.*

The ventral supporting rods (Figs. 20—22) are especially characteristic of the pedicels and so may be found with these appendages in the bivium. The most completely developed (Fig. 22) is a rod straight, or slightly curved, with a hole in each expanded end. Terminal prongs may grow out (Fig. 21), and then these may branch and their ends unite to form several holes at each end (Fig. 20). Connecting links (Figs. 18, 19) to the perforated plates (Fig. 17) of the body-wall can be found, lying particularly toward the base of the pedicel. So far these ventral supporting rods have not been found in their typical form in the dorsal pedicels. In some Holothurids they seem to be missing from the ventral pedicels. The curved rib-like rods of the papilla, in their typical form, are not found in the pedicel.

e. ASSOCIATION OF FORMS OF AMBULACRAL APPENDAGES WITH TYPES OF END-PLATES.

In the analysis of the characters of the pedicel and the papilla it is necessary to show which characters are associated together. The following data are from the dorsal region. Of the appendages with *Type A* of end-plate 32 (78·5 °/₀) are cylindrical, none conical and 9 (21·9 °/₀), not determinable. This type may be considered as typical for the completely established pedicel. The association of *Type B* is not determinable in 21 cases (58·3 °/₀), but since the remaining 15 (41·6 °/₀) are with cylindrical appendages and none with conical, it may be assumed that this, like *Type A*, is characteristic of the pedicel. Sometimes perhaps the presence of *Type B* may indicate that the pedicel is not fully developed.

Type C, only found in 9 °/₀ of the dorsal appendages, has a frequency of 2 (25 °/₀) in cylindrical, 2 (37·5 °/₀) in conical forms, and 3 (37·5 °/₀) not determinable. This type may be taken as an intermediate stage.

Type D occurs but once and then the form of its appendage is not determinable.

f. ASSOCIATION OF SUCKERS WITH TYPES OF END-PLATES.

Of the appendages with *Type A* end-plates 39 (95·1 °/₀) have suckers and 2 (4·9 °/₀) are not determinable and with *Type B* 32 (88·9 °/₀) have suckers, 1 (4·9 °/₀) has a rudimentary sucker, and 3 (8·3 °/₀) are not determinable. As none have them absent in these two classes and only 1 with *Type B* is rudimentary it may be assumed as the rule that *Types A* and *B* of end-plates are found in appendages having suckers.

With *Type C* the suckers are present in 2 (25 °/₀), rudimentary in 1 (12·5 °/₀), absent in 3 (37·5 °/₀) and not determinable in 2 (25 °/₀) of the appendages. The one case with *Type D* is uncertain but probably has a rudimentary sucker.

g. ASSOCIATION OF SUPPORTING RODS WITH TYPES OF END-PLATES.

Of the dorsal appendages with *Type A* end-plates, supporting rods are present in 16 (39 °/₀), absent in 17 (41·5 °/₀) and not determinable in 8 (19·5 °/₀); with *Type B* they are present in 4 (11·1 °/₀), absent in 17 (47·2 °/₀) and not determinable in 15 (41·7 °/₀); with *Type C* they are present in 5 (62·5 °/₀), absent in 1 (12·5 °/₀) and not determinable in 2 (25 °/₀); and in the only one with *Type D*, the rods are present.

h. CONCLUSIONS AND DEFINITIONS.

In the evolution by degeneration of the papilla from the pedicels the form has become conical with more and more pointed tip, the sucker rudimentary and finally lost, the end-plates smaller to vestigeal rosettes and supporting rods more frequent. The smaller diameter of the end-plates in the bivium, with the addition there of *Type D*, and more of *Type C*, indicates the greater progress of this evolution in the dorsal region.

The typical pedicel is cylindrical in form, with functional sucker, having end-plates of *Type A* in a large majority of the cases, the rest being of *Type B*, and dorsally with supporting rods more often absent than present.

The typical papilla is conical in form, without sucker, having end-plates of *Type D*, or *E*, and with supporting rods present.

As a connecting link between the typical pedicel and papilla is an appendage not definitely cylindrical, or conical, with suckers either present, rudimentary, or absent, having end-plates of *Type C.*

I. The Calcareous Ring.

The typical radiale of the adult (Plate V. Fig. 93), is convex anteriorly and slightly concave posteriorly. The anterior half is somewhat expanded, the sides sloping in for about one-half the length when they become straight at the junction with the inter-radialia. At the middle of the rounded anterior margin of the radiale is the notch for the radial nerve. It is 1 mm. wide, cutting into the piece for $\frac{1}{3}$ of its length and slightly increasing in breadth toward the bottom. The surface rises up from the edge of the notch to a ridge along either side. These meet a similar ridge which arises from the posterior margin. In its greatest dimensions the radiale is about 6 mm. long, 6 mm. wide, and 2 mm. thick. In the young (Fig. 97) the radiale is more delicate, more regular in outline and with the median anterior notch V-shaped and decreasing in breadth toward the bottom.

A variation (Fig. 94), not hitherto described, is often found in which there are two additional small notches cutting into the anterior margin, one toward each side. Sometimes only 1 of these notches may be found. This variate often occurs together with the normal form in the same animal.

The interradiale of the adult (Fig. 95) has a concave posterior margin and the sides run in and forwards from the lines of junction with the radialia to the anterior rounded point, thus giving the piece a somewhat triangular form. Two ridges follow the sides to unite behind the anterior end. In the young (Fig. 98) the interradiale is more delicate and the anterior sides are deeply concave, thus leaving the median portion as a bold projection.

In specimen 5 (which has only 16 tentacles) there is a fusion of the ventral and left ventral radialia and the intervening left ventral interradiale (Fig. 96). The dotted lines give the outlines of the attachment of the ventral and left ventral radial muscles.

The increase in size of the pieces of the calcareous ring, as age advances, is demonstrated by the 3 following specimens; 94, about midway in the range of the young, 42, a small adult and 56, a fairly large adult:—

SPECIMEN		RADIALE		INTER-RADIALE	
Number Serial	Volume c.c.	Length mm.	Width mm.	Length mm.	Width mm.
94	21	2·8	2·8	1·6	1·5
42	59	4·0	3·8	2·5	2·5
56	485	5·0	4·8	3·6	3·6

J. Polian Vesicles.

As a general rule the Polian vesicles are club-shaped and may be simple or branched (Fig. B, S, Br), coming off from the water-vascular ring as solitary vesicles, or so close together that it is difficult to determine the separate origins of some, or all, of the vesicles of a group.

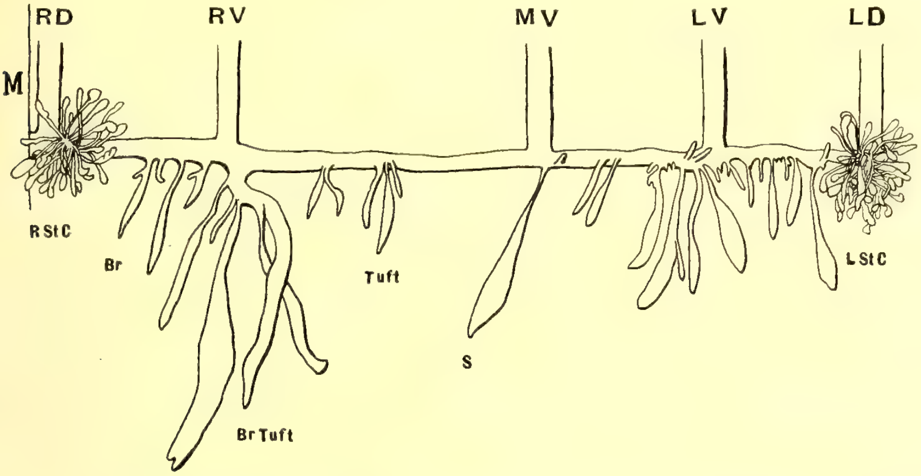


FIG. B. Water-vascular ring with Polian vesicles and stone-canals. M, Mid-dorsal mesentery. Radial canals; RD, right dorsal; RV, right ventral; MV, mid-ventral; LV, left ventral; LD, left dorsal; R St C, L St C, right and left stone-canals; S, simple, Br, Branched, Br Tuft, tuft with branched vesicles. × 5¼.

Such a group, when made up of simple vesicles, I have called a tuft (Fig. B, Tuft). When some, or all of the vesicles, are branched and arise either from the base of one of the vesicles of the group (Br Tuft) or directly from the water-vascular ring, it is a tuft with branched vesicles.

There are two principal groups of Polian vesicles in the region opposite the bases of the right and left ventral radial canals with small tufts and solitary vesicles in the ventral region between (Fig. B). Sometimes, as in 75 (Table II.) a Polian vesicle may have its origin near the dorsal mesentery, and again they may come off from the entire extent of the water-vascular ring. In 3 (Table I.) one Polian vesicle arises from a radial canal between the tentacle and water-vascular ring, and in 40 one large vesicle arises from the right dorsal radial canal just below the calcareous ring.

The most interesting case is specimen 17, which has a total of 92 vesicles and branches of which 32 are solitary, and of these, 3 have each 1 branch. There are 9 tufts ranging from 2—7 vesicles in a tuft. In addition there are 2 tufts with branched vesicles; the first with 2 simple vesicles and 1 with 1 branch, 1 with 3 and 1 with 4 branches.

The branching of vesicles and the formation of tufts and tufts with branched vesicles are due to the continued growth and multiplication of these organs along with the growth of the adult Holothurid, for 36 °/₀ of the adult have tufts and tufts with branched vesicles, while only 4 °/₀ of the young have tufts and none have tufts with branched vesicles. Ludwig, 1889–92, p. 113, gives *H. mexicana* and *H. africana* among the species in which several vesicles spring from a common stalk. Because of the variation in size of both vesicles and branches, in order to simplify the matter, in making Table XXII. I have grouped vesicles and branches together.

TABLE XXII.

Polian Vesicles.

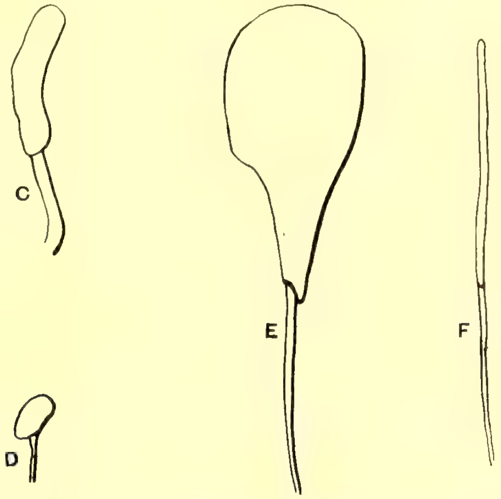
	Adult; 73 Specimens		Young; 45 Specimens	
	Number of Vesicles and Branches	Greatest Length mm.	Number of Vesicles and Branches	Greatest Length mm.
Mean	12·563 ± 1·263	25·429 ± 1·002	2·667 ± ·321	10·140 ± ·801
Standard Deviation ...	15·774 ± ·893	12·058 ± ·687	2·494 ± ·177	6·822 ± ·506
Coefficient of Variation ...	125·550 ± 7·107	47·427 ± 2·703	93·513 ± ·665	64·278 ± 4·893
Range of Variation ...	1—92	8—73	0—16	2—29

The mean number of Polian vesicles and branches is 13 with a range of 1—92, in the adult, and only 3 with a range of 0—16 in the young. Eighteen per cent. of the adult have only 1 vesicle while 74 °/₀ of the young have 1, 12 °/₀ have 2 and only 14 °/₀ have more than 2 vesicles.

The mean greatest length increased from 10 mm. with a range of 2 mm.—29 mm. in the young to 25 mm. with a range of 8 mm.—73 mm. in the adult. These facts demonstrate that, as in the formation of branches and tufts noted above, the number of vesicles and branches and their length increase with the growth of the Holothurid. Ludwig, 1889–92, p. 114, notes that most species have only 1 vesicle in the beginning, and that there are only 3 families in which these organs fail to increase in number. It is possible that most authors do not include the branches in the number of Polian vesicles given. Lampert, 1885, p. 85, notes 2 branches on the Polian vesicles. Not counting the branches, from Table I. it is found that the mean number of vesicles in the adult is 11, the four largest numbers being 40, 41, 58 and 79. Lampert, 1885, p. 85, remarks that in *H. mexicana* the Polian vesicles are very inconstant and may be conceived of as in continuous multiplication. Ludwig, 1889–92, p. 115, gives the number of Polian vesicles in *H. mexicana* as 1—13. Théel, 1886, p. 175, in describing *H. africana* says: "The Polian vesicles are numerous, up to 12 or more, of unequal size and some of them carry small branches at their base." From my series, as given above, the range of variation is greatly increased.

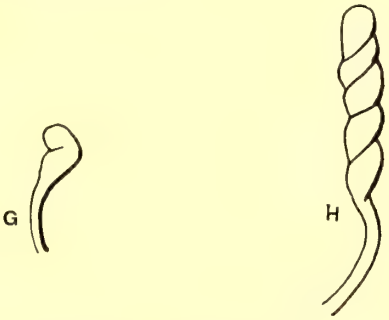
K. Stone-canals and Madreporites.

As a rule the stone-canals appear in two tufts, one slightly ventral of the base of each dorsal radius (Fig. B, R St C and L St C). In some cases from 1—7 stone-canals are separated in a line extending to 10 mm. from the dorsal mesentery.



FIGS. C—F. Stone-canals and madreporites. C, cylindrical; D, spherical; E, pear-shaped; F, profile of E. $\times 5\frac{1}{3}$.

In the majority of cases the madreporite is cylindrical (Fig. C), less frequently spherical (Fig. D), or pear-shaped (Fig. E). The head is compressed from side to side, presenting a narrow profile (Fig. F).



FIGS. G, H. Cylindrical madreporites. G, partly twisted; H, twisted in a spiral. $\times 8$.

Often a cylindrical madreporite is twisted upon itself (Fig. G), or even has as many as 4 or 5 turns of a spiral (Fig. H), and frequently the stone-canals are twisted.

At times 2 madreporites are joined together. In 16, six such united pairs occur in the left tuft. In other individuals 3, 4 or 5 madreporites may be fused, and Fig. I shows a monster composed of 6 stone-canals with the madreporites forming a common enlarged madreporic body, while the stone-canals are shortened and independent except the middle two, which have grown together. Only one stone-canal was found with 2 branches.

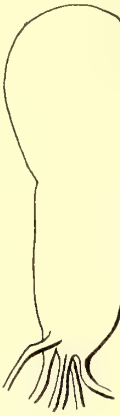


FIG. I. Six stone-canals with madreporites fused. × 5⅓.

TABLE XXIII.

Stone Canals.

	ADULT; 73 SPECIMENS					YOUNG; 45 SPECIMENS				
	Number			Greatest Length mm.	Average Length mm.	Number			Greatest Length mm.	Average Length mm.
	Right	Left	Total			Right	Left	Total		
Mean	21·589 ±1·255	15·836 ± ·980	37·479 ±1·954	7·959 ± ·327	5·368 ± ·137	6·223 ± ·410	3·556 ± ·256	9·556 ± ·605	3·444 ± ·228	2·983 ± ·150
Standard Deviation ...	15·903 ± ·888	11·894 ± ·664	24·748 ±1·381	4·140 ± ·231	1·734 ± ·097	4·076 ± ·290	2·543 ± ·180	6·021 ± ·430	2·266 ± ·161	1·488 ± ·106
Coefficient of Variation	73·663 ±4·112	75·104 ±4·192	66·030 ±3·686	52·016 ±1·287	32·311 ±1·804	65·504 ±4·657	71·523 ±5·085	63·006 ±4·410	65·806 ±4·678	49·683 ±3·532
Range of Variation ...	4—88	1—61	5—149	3—21	1·5—10·5	1—15	0—11	2—25	1—7	1·0—6·0

In the adult the mean number of right canals is 22, with a range of 4—88, and of left canals 16, with a range of 1—61. In the young the mean number of right canals is 6, with a range of 1—15 and of left canals 4, with a range of 0—11. Thus the mean number of right canals is 36 °/₀ greater than that of the left in the adult and 75 °/₀ greater in the young. This interesting asymmetry is noted for a number of species by Ludwig, 1889–92, p. 132, who gives *H. mexicana* with 8 left and 3 right canals. I find that 78 °/₀ of both the adult and young have the greater number of canals on the right side, while only 15 % of the adult and 9 % of the young have the number greater on the left side, and 1 % of the adult and 13 % of the young have the same number on both sides. So Ludwig must have made his counts from the less frequent individuals in which the number on the left is greater.

In both adult and young the standard deviation and range of variation are greater for the right canals.

In the adult the mean total number of stone-canals is 37, with a range of 5—149, and in the young 10, with a range of 2—25, demonstrating the great increase in the number of these organs through continued budding as the Holothurid grows. Specimen 68 with the large number of 149 stone-canals is exceptional, but 37 % of the adult have more than 40 stone-canals. This should be particularly noted since Ludwig, 1889–92, p. 131, mentions *H. mexicana* as having a range of from 11—40 stone-canals. Lampert, 1885, p. 85, gives them as very numerous in two specimens of *H. mexicana.*

The mean greatest length is 8 mm. with a range of 3 mm.—21 mm. in the adult and 3 mm. with a range of 1 mm.—7 mm. in the young. To determine the average length of all the canals of an individual the mode was selected by inspection and measured. The mean average length is 5 mm. with a range of 1·5 mm.—10·5 mm. in the adult and 3 mm. with a range of 1 mm.—6 mm. in the young. Thus the number of stone-canals and their length together with their standard deviations increase with age.

L. Gonads.

The gonads are branched and form a tuft to the left side of the dorsal mesentery. The gonaduct opens dorsally just behind the circlet of tentacles. In most individuals, the sex cells mature in July and August (Edwards, 1889, p. 37).

Of the 73 adults, 35 are male, 35 female, 1 undifferentiated and 2 with gonads missing. Of the 45 young, 14 are male, 12 female, 12 undifferentiated and 7 with gonads missing.

M. Respiratory Trees.

Each of the two main stems of the respiratory tree has short branches whose median terminal twigs are intertwined with the blood-vessels of the rete mirabile.

N. The Enteric Canal.

The enteric canal is in three loops supported by a mesentery attached to the body-wall. It is large, with delicate wall and always crowded full with calcareous sand. At the posterior end is the expanded cloaca, its tough wall being attached to the body-wall by numerous small muscles.

O. Habitat.

ATLANTIC OCEAN: FLORIDA, Pourtalés, 1851; Selenka, 1867; MEXICO, Ludwig, 1874; WEST INDIES, Lampert, 1885; CUBA, *Havana*, Ludwig, 1883; Lampert, 1885; JAMAICA, Ludwig, 1883; PORTO RICO, Clark, 1901; ST THOMAS, Lampert, 1885; ST BARTHOLOMEW, GUADALOUPE, Théel, 1886; VENEZUELA, *Puerto Cabello*, Ludwig, 1883; Lampert, 1885; AZORES, Hérouard, 1902; AFRICA, CAPE OF GOOD HOPE, *Simon's Bay*, Théel, 1886.

The specimens in this paper are from BAHAMAS, ABACO, *Green Turtle Cay*; NEW PROVIDENCE, *Nassau*; FLORIDA, *Elliott's Key, Key Largo, Caesar's Creek, Indian Key, Vaca Key, Bahia Honda, between Salt Pond Key and Stock I., Key West, Tortugas*; PORTO RICO, *Boqueron Bay, Fajardo, Mayaquez, San Juan*; CUBA, *Havana*; HAITI; ST THOMAS; CARIBBEAN SEA, *Swan I., Curacoa I.*

Semper, 1868, p. 88, says that Holothurids of this species live together in great crowds upon sandy places of the coral reefs, and ordinarily are so completely covered with small sand-grains that they are noticed only by the trained eye. Gardiner, 1901–3, 1908, notes this species as one of the sand-feeders found on the sand-flats and reefs within the lagoons of the coral reefs.

III. HOLOTHURIA ATRA JÄGER.

For the characters in which *H. atra* is like *H. floridana* I will simply refer to the descriptions given above. Tables of the characters observed are given as XXIV. and XXV. on pp. 275 and 276.

A. Body.

a. FORM.

Similar to *H. floridana.*

b. SIZE.

TABLE XXVI.

1. *Length in cm.*

	Adult	Young
Number of Cases	12	8
Mean	16·367 ± 1·475	8·200 ± ·628
Standard Deviation ...	7·577 ± 1·043	2·634 ± ·424
Coefficient of Variation ...	46·295 ± 6·374	32·121 ± 5·416
Range of Variation ...	10·0—33·5	2·5—11·0

TABLE XXIV.

H. atra Jäger. Adult.

Serial Number	Length cm.	Diameter cm.	Volume cm.^{3}	Average Thickness of Skin mm.	Sex	Polian Vesicles			Stone Canals							Pedicels and Papillae		Museum Number	
						Total Number	Length mm.		Number			Length mm.		Number		Distribution per sq. cm.			
							Greatest	Least	Right	Left	Total	Greatest	Average	Tentacles	Groups of Anal Papillae	Dorsal	Ventral	Smithsonian Institution	Harvard
150	13·6	4·1	89·78	1·5	♀	1	12	—	7	8	15	11	10·0	20	5	30	74	—	616
151	33·5	6·5	538·49	1·5	♂	19	15	1	11	10	21	8	6·0	19	*i*	8	54	—	1103
152	23·0	4·8	208·10	1·0	♀	35	15	2	9	9	18	6	5·5	20	*i*	16	42	—	1103
153	29·0	6·0	409·98	3·0	♂	36	17	1	7	10	17	16	10·0	20	4	13	41	—	1103
154	10·0	3·8	56·71	1·5	♂	4	22	1	4	11	15	7	6·5	20	5	11	60	—	1053
155	11·3	3·6	57·51	0·5	♂	5	10	2	13	11	24	6	5·5	20	*i*	10	30	6892	—
156	10·8	4·2	74·82	1·5	♂	56	19	12	12	7	19	9	7·5	20	5	8	21	6892	—
157	18·9	4·7	163·96	3·0	+	50	10	1	8	8	16	16	6·0	20	*i*	17	57	—	—
158	21·9	7·6	496·75	4·0	♂	29	42	1	10	9	19	13	11·0	19	5	8	32	6894	—
159	12·8	3·8	72·59	2·0	♂	8	10	1	10	11	21	5	4·5	18	*i*	27	38	—	1055
160	12·3	3·2	49·46	1·5	+	2	9	1	27	43	70	8	5·0	18	*i*	21	36	—	640
161	11·8	5·3	130·17	1·5	+	8	16	1	25	9	34	8	5·0	21	*i*	26	48	—	640

+ undifferentiated. *i* indefinite. In 157 the Polian vesicles arise from the entire extent of the ring-canal. The volume of 160 is not quite 50 cm.^{3} 150—154, Hawaiian Is.; 155, Apia, Samoa; 157, Society Is.; 158, Tahiti; 159, Arabian Sea; 160, 161, Zanzibar. All but 157 and 158 were originally identified as *Holothuria floridana* Pourtalés.

TABLE XXV.

H. atra Jäger. Young.

Serial Number	Length cm.	Diameter cm.	Volume cm.^{3}	Average Thickness of Skin mm.	Sex	Polian Vesicles			Stone Canals							Pedicels and Papillae		Harvard Museum Number
						Total Number	Length mm.		Number			Length mm.		Number		Distribution per sq. cm.		
							Greatest	Least	Right	Left	Total	Greatest	Average	Tentacles	Groups of Anal Papillae	Dorsal	Ventral	
162	8·0	2·9	26·42	1·5	?	4	11	1	6	2	8	8	7·0	20	5	41	60	1053
163	7·8	2·8	24·02	1·5	+	4	9	1	8	5	13	4	3·5	20	*i*	22	58	?
164	10·7	2·4	24·20	1·5	+	24	17	1	5	7	12	5	5·0	20	5	30	62	1473
165	9·0	3·2	36·19	1·5	?	8	15	3	7	5	12	2	1·0	18	*i*	32	70	1473
166	6·5	2·1	11·26	1·0	+	10	15	2	1	8	9	3	2·5	18	0	39	100	1473
167	2·5	1·4	1·93	1·5	+	10	8	1	11	8	19	6	4·0	20	0	34	91	411
168	11·0	1·8	14·00	1·0	+	7	21	1	13	8	21	4	4·0	17	5	?	?	439
169	9·7	2·6	25·75	1·5	+	14	8	1	11	7	18	6	5·0	20	*i*	18	61	439

? Missing. + undifferentiated. *i* indefinite. 164 has most of the madreporites fused. 162, Hawaiian Is.; 163, Marshall Is.; 164—167, Zanzibar; 168, 169, Mozambique.

TABLE XXVII.

2. *Diameter in cm.*

	Adult	Young
Number of Cases	12	8
Mean	5·383 ± ·286	2·325 ± ·212
Standard Deviation ...	1·470 ± ·202	·600 ± ·101
Coefficient of Variation ...	27·314 ± 3·760	25·785 ± ·435
Range of Variation ...	3·2—7·6	1·4—3·2

TABLE XXVIII.

3. *Volume in cm.³* $v = \frac{\pi l r^2}{2}$.

	Adult	Young
Number of Cases	12	8
Mean	170·335 ± 33·450	20·200 ± 2·495
Standard Deviation ...	171·793 ± 23·653	10·461 ± 1·764
Coefficient of Variation ...	100·856 ± 13·886	51·788 ± 8·733
Range of Variation ...	49·46—538·49	1·93—36·19

B. Colour.

The colour was determined from alcoholic specimens by the method described on p. 244 for *H. floridana.*

a. COLOURATION.

1. *Pedicels and Papillae.* The dorsal stalks of the adult are seal-brown in all but one individual in which they are light Prout's brown, while the ventral stalks are seal-brown except in two cases of light sepia, and one where some are drab with a ring of seal-brown. In the young both the dorsal and ventral stalks are seal-brown except in one individual where they are of the darker clove-brown. The ends of the appendages are generally coloured like the stalks, or of some lighter tint, like sepia, clay-colour, Isabella-colour, or cinnamon. Semper, 1868, p. 88, describes the ends as whitish in life.

2. *Distribution of Colour on the Body.* As graphically shown in Plate I. 160—167, the body is almost always of a uniform seal-brown. Two of the adults have blotches of light sepia on the ventral side and one has Prout's brown mid-dorsally. One of the young has a circumanal ring of dark pearl gray and another is clove-brown. Sluiter, 1895, notes a red (*steinrot*) colour in life. Pearson, 1903, speaks of some specimens when alive being quite black above but pink below. Sluiter,

1894, thinks that the variety *amboinensis* must be given up because of colour intermediates from deep black to clear yellow at the basis from which the ambulacral appendages arise.

TABLE XXIX.

C. Tentacles and Ampullae.

a. NUMBER OF TENTACLES.

	Adult	Young
Number of Specimens ...	12	8
Mean	19·583 ± ·169	19·125 ± ·278
Standard Deviation ...	·868 ± ·120	1·166 ± ·196
Coefficient of Variation ...	4·430 ± ·610	6·096 ± 1·028
Range of Variation ...	18—21	17—20

The 20 tentacles normally found as the mode in *H. atra* are distributed according to the scheme of symmetry given for *H. floridana* (cf. Fig. A, Pl. V.).

Variation in the Number of Tentacles and the Relation of those Present to the Normal Symmetry.

TABLE XXX.

Variations with less than 20 Tentacles.

Distribution in accord with the scheme of symmetry given in Fig. A. Absence of tentacle in particular radius indicated by 0.

Age	Serial Number	Right Dorsal				Left Dorsal				Right Ventral				Left Ventral				Mid-Ventral				Total Number
		d1	*d2*	*v2*	*v1*	*d1*	*d2*	*v2*	*v1*	*d1*	*d2*	*v2*	*v1*	*d1*	*d2*	*v2*	*v1*	*l1*	*l2*	*r2*	*r1*	
Adult	*151*	—	—	—	—	—	0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	19
	158	—	—	—	—	—	0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	19
	159	—	—	0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0	—	—	18
	160	—	—	—	—	—	—	0	—	—	—	0	—	—	—	—	—	—	—	—	—	18
Young	*165*	—	0	—	—	—	—	—	—	—	—	—	—	—	0	—	—	—	—	—	—	18
	166	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0	0	—	18
	168	—	0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0	0	—	17

Among the 8 variates there is the same decided tendency to reduction in the number of tentacles as shown in *H. floridana*, since 7 (87·5 $^{\circ}/_{\circ}$) have less than the normal number of 20. Only 1, an adult, 161, with 21 tentacles has more than the norm. The extra tentacle is *d3*, left dorsal radius, and all 5 tentacles of the dorsal inter-radius are in asymmetry, to the left of the mesentery. In 151, 158 and 160 the mesentery is attached at the junction of the dorsal inter-radiale with the right dorsal radiale; in 161, far over on the right dorsal radiale.

b. BRANCHES ON TENTACULAR AMPULLAE AND VARIATION IN THEIR NUMBER.

Only 1 Holothurid, 151, varies from the norm in having branches to the ampullae. There are in all 25 branches distributed as follows: right dorsal radius *d*2 (1), *v*2 (1), mid-ventral radius *rl* (1), *r*2 (2), *l*2 (1), *l*1 (5), left ventral radius *v*1 (1), *v*2 (1), *d*2 (1), left dorsal radius *v*1 (2), *v*2 (1), *d*1 (8). This case is even more remarkable than 7 of *H. floridana* (p. 252), and since with a volume of 538 cm.^{3} it is the largest individual in the series it shows that the branching of the ampullae, when it appears, is associated with the more advanced age. One specimen, 155, has 1 of its tentacles of small size.

D. Pedicels and Papillae.

a. DISTRIBUTION PER SQ. CM.

(Counted as in *H. floridana*, p. 253.)

TABLE XXXI.

	DORSAL		VENTRAL	
	Adult	Young	Adult	Young
Number of Specimens ...	12	8	12	8
Mean	16·584 ± 1·612	30·572 ± 2·011	44·500 ± 2·651	72·714 ± 4·114
Standard Deviation ...	8·281 ± 1·140	7·889 ± 1·422	13·617 ± 1·875	16·138 ± 2·909
Coefficient of Variation ...	49·935 ± 6·875	25·807 ± 4·652	30·599 ± 4·213	22·194 ± 4·001
Range of Variation ...	8—30	18—41	21—74	58—100

Table XXXI. demonstrates that in the adult there are 2·6 as many appendages in the ventral region as in the dorsal, and in the young 2·4 as many. In both the adult and young the standard deviation is much greater in the ventral region*. Compared with *H. floridana*, the appendages are more numerous and crowded, especially in the trivium. Selenka, 1867, p. 326, notes that the ventral pedicels are more numerous in the older examples. Östergren, 1907, p. 195, notes the presence among the larger pedicels of numerous very small pedicels which hold fast the protective covering of weeds and other foreign bodies.

[* In this as in several other cases cited by the author, the statement as to variability depends upon using the standard-deviation and not the coefficient of variation as the measure of variability.—ED.]

TABLE XXXII.

b. DISTRIBUTION OF PAPILLAE AROUND THE ANUS.

Age	In Groups						Indefinite	Total
	Number of Groups							
	0	*1*	*2*	*3*	*4*	*5*		
Adult ...	0	0	0	0	1	4	7	12
Young ...	2	0	0	0	0	3	3	8

Table XXXII. shows that all of the adults have anal papillae. In 42 $^{\circ}/_{\circ}$ the papillae are in groups, and in 58 $^{\circ}/_{\circ}$ they are indefinitely distributed. Of the 8 young, two have no anal papillae, three have 5 groups and three have the papillae indefinitely distributed.

E. The Body-wall.

a. THICKNESS IN MM.

(Determined as in *H. floridana*, p. 256.)

TABLE XXXIII.

	Adult	Young
Number of Specimens ...	12	8
Mean	1·717 ± ·173	1·575 ± ·052
Standard Deviation ...	·886 ± ·122	·217 ± ·037
Coefficient of Variation ...	51·599 ± 7·104	13·746 ± 2·318
Range of Variation ...	·6—4·0	1·0—1·5

The mean thickness of the body-wall is only ·14 mm. greater in the adult than in the young. The range in the adult shows one 4 mm. thick, but in most cases it cannot be said to grow much thicker with age, in which it differs decidedly from *H. floridana* (cf. p. 256). In *H. floridana* the mean thickness of body-wall is 2·4 greater than in *H. atra*. Thus the body-wall in *H. atra* is comparatively thin, soft and flaccid while in *H. floridana* it is nearly always much thicker, and even when not thicker, it is usually hard and firm, especially in the adult. Lindmann, 1899, claims that in the changes of consistency in the body-wall from hard to soft the albuminous element of the slime-secretion plays the most important part. While this may be true of the physiology of these tissues, yet I should account for the specific difference above noted in the greater thickness and the much larger number of spicules found in the body-wall of *H. floridana* (cf. p. 256). The standard deviation, especially in the young of *H. atra*, is very small.

b. Pits.

Over most of the surface of the body and the ambulacral appendages are found shallow, crater-like depressions which may be called pits (Fig. J).

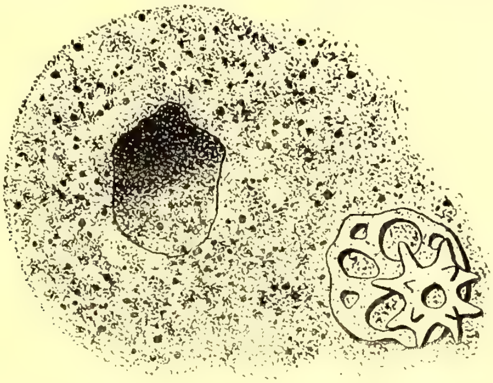


Fig. J. Pit with thick, pigmented wall. A table lies just beyond the outer edge of the pit. × 320.

The mean dimensions are about ·15 mm. × ·1 mm. and their centres, in general, average about ·3 mm. apart. Each has a thickened pigmented wall (Fig. K) in which epidermal cells are crowded and which is more or less clearly separated from the surrounding tissue by crescentic clefts (x).

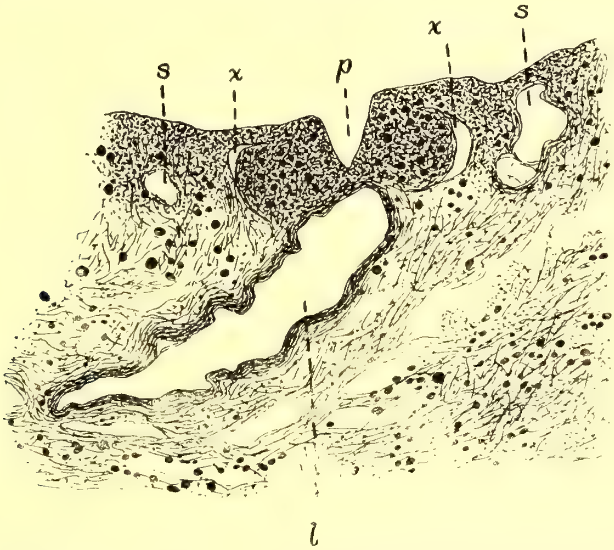


Fig. K. Section of pit; p, pit; x, x, clefts separating wall from surrounding tissues; l, lacuna; s, s, spaces from which tables have been dissolved. × 400.

The opening of the pit is either approximately circular (Fig. J) or else slightly elongated and about ·057 mm. × ·03 mm. At times when the lip of the pit is nearly closed the opening is a narrow slit. In sections it is seen that beneath the blind bottom of the funnel-shaped pit (Fig. K) there is a closed lacunar space, sometimes spherical, but more frequently drawn out into an elongated canal-like space (*l*). The sections show the characteristic loosely woven connective tissue fibres and the spaces (*s*) from which spicules like the tables in (Fig. J) have been dissolved. Fisher (1907) seems not to have noticed my preliminary paper (1905) in which these pits were first mentioned, and hence has failed to include in his description these and some of the other characters by means of which I have clearly differentiated *H. atra* from *H. floridana*.

F. Calcareous Spicules of the Body-wall.

The spicules are not so numerous as in *H. floridana* and the warts found in that species do not occur.

a. TABLES.

For the general description of the development, structure and variation of the tables there is no distinction to be made from *H. floridana* (cf. p. 256 *et seq.*).

b. TABLES OF BIVIUM AND TRIVIUM IN H. ATRA.

For this study data were taken from 16 specimens collected all the way from the Hawaiian Islands to Mozambique. Ordinarily 10 tables were taken from each

TABLE XXXIV.

Tables of Bivium and Trivium.

		DISC				CROWN			
		Number of Peripheral Holes	Number of Spines	Diameter μ	Height μ	Number of Teeth	Diameter of Hole μ	Diameter not including Teeth μ	Diameter including Teeth μ
Dorsal	Mean	3·740 ± ·069	·713 ± ·097	47·927 ± ·251	65·870 ± ·590	11·960 ± ·055	9·225 ± ·148	19·710 ± ·156	44·030 ± ·300
	Standard Deviation	1·257 ± ·049	1·753 ± ·683	4·558 ± ·178	9·780 ± ·416	·999 ± ·039	2·637 ± ·105	2·779 ± 1·101	5·439 ± ·212
	Coefficient of Variation	31·008 ± 1·208	245·65 ± ·957	9·511 ± 3·704	14·840 ± ·624	8·355 ± ·325	28·580 ± 1·136	14·100 ± ·569	12·350 ± ·500
	Range of Variation	0—9	0—10	35·2—60·8	41·92—92·22	8—15	3·2—19·2	12·8—25·6	32·0—57·6
Ventral	Mean	3·578 ± ·094	·669 ± ·094	44·603 ± ·326	47·629 ± ·449	12·162 ± ·063	9·190 ± ·155	18·780 ± ·150	38·756 ± ·337
	Standard Deviation	1·652 ± ·066	1·667 ± ·068	5·763 ± ·231	7·355 ± ·318	1·117 ± ·045	2·709 ± ·110	2·626 ± ·106	5·953 ± ·238
	Coefficient of Variation	46·100 ± 1·845	249·07 ± ·997	12·920 ± 5·199	15·432 ± ·068	9·187 ± ·367	29·476 ± 1·192	14·000 ± ·577	15·350 ± ·623
	Range of Variation	0—9	0—9	28·8—60·8	31·1—70·0	8—15	3·2—16·0	12·8—28·8	25·6—57·6

of the dorsal and ventral regions. The determinations for the species, recorded in Table XXXIV. were made from a total of 150 dorsal and 142 ventral tables.

1. *Disc.*

In the form of the disc, *dorsally* there are 119 (79·3 °/₀) square, 13 (8·7 °/₀) irregularly square, 13 (8·7 °/₀) round, 2 (1·3 °/₀) irregularly round, and 3 (2 °/₀) irregular; *ventrally*, 92 (64·8 °/₀) square, 16 (11·3 °/₀) irregularly square, 18 (12·7 °/₀) round, 7 (4·9 °/₀) irregularly round, 9 (6·3 °/₀) irregular. In general, square may be taken as the prevailing form.

The mean number of peripheral holes is 4, which is from 1 to 2 less than in *H. floridana.* Pearson, 1903, p. 202, notes that "the discs of the tables are smooth and have no peripheral perforations." The study of my series shows that Pearson's description cannot be held as typical for the species.

The mean number of spines is ·7 while 82 °/₀ of the tables have discs without spines. In all of the characters of the disc this species agrees closely with *H. floridana* (cf. p. 258).

2. *Height.*

The dorsal tables are 66 μ high, 38 °/₀ higher than the ventral, and altogether they are higher in *H. atra* than in *H. floridana.*

3. *Crown.*

The mean diameter, both including and not including teeth, the length of the teeth and the mean diameter of the hole, are slightly greater in this species than in *H. floridana.*

The mode for the number of teeth is 12; the mean being slightly less dorsally and slightly more ventrally.

As in the case of *H. floridana,* the dorsal tables have more peripheral holes, more spines, broader crown, larger crown-hole and longer teeth than the ventral tables, albeit in some characters the differences are so small as scarcely deserving of notice, while the number of teeth is slightly greater ventrally.

c. ROSETTES AND ROSETTES WITH HOLES.

In its simple condition the rosette has a somewhat elongated central bar with forked ends (Pl. IV. Fig. 23). The ends fork (Fig. 24), and the branches thus formed grow toward one another. Later additional branches may appear at the middle of the central bar (Fig. 25). A large majority of the rosettes remain open as in Figs. 24 and 25, although the curved ends of contiguous branches are often in apposition. On some of the rosettes are little knobs, while others present slight irregularities of the surface which might be taken for knobs.

When the distal portions of any two of these branches fuse, a hole is formed (Fig. 26) and such a spicule is placed in the class of rosettes with holes (Figs. 26—27 f). In the bivium there are 145 (96·7 °/₀) rosettes and 5 (3·3 °/₀) rosettes with holes, and in the trivium 130 (86·7 $^{\circ}/_{\circ}$) rosettes and 20 (13·3 $^{\circ}/_{\circ}$) rosettes with holes.

TABLE XXXV.

Rosettes and Rosettes with Holes.

		Rosettes		Rosettes with Holes		
		Greater Diameter μ	Smaller Diameter μ	Number of Holes	Greater Diameter μ	Smaller Diameter μ
Dorsal	Mean	24·662	17·148	1·400	24·000	19·200
		± ·220	± ·157	± ·121	± 2·569	± 1·289
	Standard Deviation ...	3·931	2·803	·400	8·518	4·293
		± ·156	± ·111	± ·085	± 1·817	± ·916
	Coefficient of Variation	15·941	16·348	28·571	35·492	22·351
		± ·631	± ·698	± 6·094	± 7·570	± 4·767
	Range of Variation ...	9·6—33·6	9·6—24·0	1—2	19·2—33·6	14·4—24·0
Ventral	Mean	24·886	17·022	1·350	26·400	18·240
		± ·279	± ·154	± ·099	± ·886	± ·369
	Standard Deviation ...	4·717	2·597	·654	5·873	2·448
		± ·197	± ·109	± ·070	± ·626	± ·261
	Coefficient of Variation	18·954	15·259	48·430	22·247	13·418
		± ·793	± ·638	± 5·165	± 2·373	± 1·431
	Range of Variation ...	14·4—43·2	9·6—24·0	1—3	19·2—38·4	14·4—24·0

In their general dimensions and the increased size of the rosettes with holes these spicules in *H. atra* agree with those of *H. floridana*. Only 3 $^{\circ}/_{\circ}$ in the dorsal region are rosettes with holes and 13 $^{\circ}/_{\circ}$ in the ventral region. Of the 25 rosettes with holes found among the 300 rosettes and rosettes with holes of my statistical series, only two have 3 holes, four have 2 holes and 19 have 1 hole.

The rosette with holes (perforated plate) of *H. atra* is often more or less similar to the developmental stages of the perforated plate in *H. floridana*. The rosettes nearly always show some of the arching of the branches of the bar (Figs. 24, 25), preliminary to the formation of the two central and the one or more distal holes of developmental *Types a* (Fig. 37) and *b* (Fig. 38) of *H. floridana*. Thus Fig. 27 a resembles *Type a*. *Type b* with the 4 additional distal holes, 2 at each end, is often clearly indicated, albeit rarely, if ever, having all the distal holes completed (Fig. 27 b). (Cf. Selenka, 1867, Pl. VII. Fig. 4.)

Occasional somewhat elongated "buttons" occur with two pairs of larger central holes and one distal hole at each end (27 c). In one case there is an incomplete button of this type but with three pairs of central holes (Fig. 27 d). This button is formed from *Type a* by the growth of a bar through each central hole. Fig. 27 a shows such a bar projecting into the right central hole. If in a rosette like Fig. 25 with median lateral bars the apposed terminal processes fused, a button like the above would result. In 156, from Samoa, there is a marked tendency toward the formation of these patterns.

But even when holes are present the ends of the rosette branches curl out and project freely, only very rarely forming the smooth contour often found in *Types a* and *b* of *H. floridana.* In my statistical series 6 $^{\circ}/_{\circ}$ have one hole (Fig. 26); 1 $^{\circ}/_{\circ}$ two holes and *only a fraction of* 1 $^{\circ}/_{\circ}$ *more than two holes* (Fig. 27). By special searching outside of the statistical series rosettes were found with as many as six holes completely formed (Figs. 27 b—d). EVEN THEN THE FULLY DEVELOPED PERFORATED PLATES OF H. FLORIDANA (Figs. 39—41), WITH A MEAN NUMBER OF 13—15 HOLES, ARE DISTINCTLY DIFFERENT FROM ANY FOUND IN H. ATRA. So also the rosettes differ in the two species. In *H. atra* they are more elongated, the parts more nearly at right angles to one another and the whole more delicate, while in *H. floridana* they are stellate, appear heavier, often thicker at the centre and the branches have swollen ends (cf. Figs. 23—27 d with 28—33). Sometimes rosettes like those of *H. atra* are found in *H. floridana*, as well as stages intermediate to the stellate form typical of the latter species. The possession of peculiar perforated plates and in almost all cases the different kind of rosettes, are among the chief characters which have led me to separate and re-establish *H. floridana* as a distinct species.

Number per sq. cm.

One hundred of these spicules were counted in the field (·2 sq. mm.) of a 1 in. ocular and a $\frac{1}{4}$ in. objective, and thus to each sq. cm. of surface there could be 50,000 spicules. The possible error in this calculation may be placed at 50 $^{\circ}/_{\circ}$. As a general rule these spicules are much more crowded in *H. floridana* (cf. p. 263) but there are exceptions like 30 of that species, which has scarcely more spicules than the least number in *H. atra.*

G. Calcareous Spicules of the Ambulacral Appendages and the Differentiation of Pedicels and Papillae.

From 13 Holothurids, 204 dorsal ambulacral appendages were taken, and from 3 specimens, 53 ventral appendages. Certain characters were not determinable, or absent, in some cases.

a. Form.

In form 18 (8·8 $^{\circ}/_{\circ}$) are cylindrical, 26 (12·8 $^{\circ}/_{\circ}$) conical, but chiefly because of much contraction, 160 (78·4 $^{\circ}/_{\circ}$) of the dorsal ambulacral appendages were not determinable. From those determined it may be assumed that a considerable majority in the bivium are conical in *H. atra*, instead of cylindrical as in *H. floridana.*

b. Suckers.

Suckers are present in 31 (15·2 $^{\circ}/_{\circ}$), rudimentary in 1 (·5 $^{\circ}/_{\circ}$), absent in 121 (59·3 $^{\circ}/_{\circ}$) and not determinable in 57 (25 $^{\circ}/_{\circ}$).

The absence of a sucker is characteristic of the papilla, and since 59 °/o of the dorsal appendages lack this organ they may be considered as papillae.

c. END-PLATES.

In 12 (5·9 °/o) of the dorsal appendages there is no trace of an end-plate, a condition which only occurs in 1 °/o of the dorsal appendages of *H. floridana.* In 2 (1 °/o) the end-plate was not determinable.

TABLE XXXVI.

Diameter of End-plates in μ.

	DORSAL					VENTRAL				
	A	*B*	*C*	*D*	*E*	*A*	*B*	*C*	*D*	*E*
Frequency	1 (·5 °/o)	89 (46·8 °/o)	70 (36·8 °/o)	22 (11·6 °/o)	8 (4·3 °/o)	38 (71·7 °/o)	10 (18·9 °/o)	3 (5·7 °/o)	1 (1·9 °/o)	1 (1·9 °/o)
Mean	450·00	283·652 ± 3·778	169·349 ± 2·262	107·727 ± 3·367	78·750 ± 4·979	669·473 ± 10·687	339·000 ± 11·720	175·001 ± 7·286	105·000	60·000
Standard Deviation	—	52·812 ± 2·670	27·858 ± 1·600	23·412 ± 2·381	20·879 ± 3·521	97·671 ± 7·557	54·950 ± 8·288	18·710 ± 5·152	—	—
Coefficient of Variation	—	18·619 ± ·941	16·450 ± ·945	21·733 ± 2·210	26·512 ± 4·471	14·589 ± 1·129	16·209 ± 2·445	10·691 ± 2·944	—	—
Range of Variation	—	225—420	105—210	60—135	60—120	465—825	240—405	150—195	—	—

In the bivium there is only one end-plate of *Type A*, with a diameter less than that of the smallest variate of this type in the trivium. *Types A*, *B* and *C* are larger and more variable in the trivium, and each of the vestigeal rosette-like end-plates, *D* and *E*, is found but once, while dorsally *D* occurs in 12 °/o and *E* in 4 °/o of the cases.

Comparing Table XXXVI. with Table XXI. it is seen that in *H. floridana* the mean diameters of all the types are larger, while in *H. atra* only one dorsal end-plate is large enough to be placed in *Type A*. So, from a consideration of the end-plates, it is obvious that the evolution by degeneration of the papilla from the primitive pedicel is much more marked dorsally in both species, and that all over the body it has proceeded decidedly farther in *H. atra* than in *H. floridana.* Selenka, 1867, p. 326, notes that specimens from the South Sea have the end-discs $\frac{1}{4}$ smaller than those from Florida.

d. SUPPORTING RODS.

Dorsal.

In the bivium supporting rods are absent in 146 (71·6 °/o) of the appendages, present in 32 (15·7 °/o) and not determinable in 26 (12·7 °/o). The description given on p. 266 covers the dorsal supporting rods of this species.

e. SUPPORTING ROSETTES AND SUPPORTING PLATES.

Ventral.

The supporting rosettes are found in the wall of the sucker near the end-plate. The terminations of the central bar are broadly branched nearly at right angles to the bar and the spreading branches are often fused to form holes (Figs. 15, 16). In some cases terminal twigs from the opposite ends grow together, thus forming perforated plates with two especially large central holes (Fig. 14). These are the fenestrated, often symmetrically bilateral plates described by Théel, 1886, p. 181.

f. ASSOCIATION OF FORM OF AMBULACRAL APPENDAGES WITH TYPES OF END-PLATES IN THE BIVIUM.

Type A only occurs once and in a cylindrical appendage. *Type B* was not determinable in 61 (67·8 °/o) cases but in the 29 (32·2 °/o) determinable is in cylindrical appendages. *Type C* is in cylindrical appendages in 3 (4·3 °/o), in conical 6 (8·7 °/o) and was not determinable in 60 (87 °/o). *Type D* was not determinable in 17 (77·3 °/o) but in the 5 (22·7 °/o) determinable is in conical appendages. *Type E* was not determinable in 4 (50 °/o) but like *Type D* when determinable, 4 cases (50 °/o), is in conical appendages.

g. ASSOCIATION OF SUCKERS WITH TYPES OF END-PLATES.

The one appendage with *Type A* end-plate has a sucker. With *Type B* suckers are present in 25 (27·8 °/o), rudimentary in 1 (1·1 °/o), absent in 33 (36·7 °/o) and not determinable in 31 (34·4 °/o). With *Type C* suckers are present in 4 (5·8 °/o), absent in 51 (73·9 °/o), and not determinable in 14 (20·3 °/o). With *Type D* suckers are absent in 20 (90·9 °/o) and not determinable in 2 (9·1 °/o), and with *Type E* present in 1 (12·5 °/o), absent in 6 (75 °/o), and not determinable in 1 (12·5 °/o). In two appendages without end-plates one has a sucker and one has not.

When compared with *H. floridana* the absence of suckers with *Type B* is especially noticeable, showing, perhaps, that the sucker is lost first and then follows the degeneration of the end-plate.

h. ASSOCIATION OF SUPPORTING RODS WITH TYPES OF END-PLATES.

In the one appendage having *Type A*, supporting rods are absent. With *Type B* they are absent in 64 (71·1 °/o) and not determinable in 26 (28·9 °/o). With *Type C* supporting rods are present in 6 (8·7 °/o), absent in 58 (84·1 °/o) and not determinable in 5 (7·2 °/o). With *Type D* they are present in 40 (40·9 °/o), absent in 54 (54·5 °/o) and not determinable in 4 (4·5 °/o), and with *Type E*, present in 4 (50 °/o) and absent in 4 (50 °/o).

In the cases determinable supporting rods are absent in appendages having end-plates of *Types A* and *B* and in the large majority of those having *Type C*, while they are about as often absent as present in those having *Types D* and *E*. In the two appendages without end-plates supporting rods are present.

i. Conclusions and Definitions.

While agreeing in general with the conclusions and definitions for *H. floridana* (p. 267), *H. atra* has part of the appendages with *Type B* end-plates, without suckers, and represents a more specialized stage in evolution, with the addition of *Types D* and *E* of end-plates in the trivium and *Type E* in the bivium.

H. The Calcareous Ring.

The calcareous ring, including the variation of the radialia with notches, is similar in form to that of *H. floridana* but about twice as large.

The growth in the pieces of the calcareous ring is shown in the two following specimens, *155*, a small adult, and *158*, a large adult:—

Specimen		Radiale		Inter-radiale	
Serial Number	Volume cm.^{3}	Length mm.	Width mm.	Length mm.	Width mm.
155	58	5·0	5·5	4·0	2·5
158	497	7·5	6·7	5·8	6·0

Selenka, 1867, p. 326, notes that specimens from the Sandwich Islands have $\frac{1}{3}$ larger calcareous ring. Comparing the area of the radiale, 28 sq. mm. in the young adult, *155*, with that of a specimen of *H. floridana* of nearly equal volume, 15 sq. mm. in *42* (cf. p. 268), it is seen that the radiale is 87 °/$_{\circ}$ larger in *H. atra*. In the same way the inter-radiale is shown to be 67 °/$_{\circ}$ larger. Comparing older adults *158* and *56* the volume of the former being 12 c.c. greater (cf. p. 268), the radiale is found to be 108 °/$_{\circ}$, and the inter-radiale 169 °/$_{\circ}$ larger in *H. atra*.

I. Polian Vesicles.

The Polian Vesicles are club-shaped and in general arise from the water-vascular ring in two principal groups opposite the bases of the right and left ventral radial canals. In one case, *157*, the vesicles arise from the entire extent of the ring-canal.

TABLE XXXVII.

Polian Vesicles.

	ADULT; 12 SPECIMENS		YOUNG; 8 SPECIMENS	
	Number of Vesicles	Greatest Length mm.	Number of Vesicles	Greatest Length mm.
Mean	20·750 ± 3·835	17·000 ± 1·639	9·500 ± 1·460	13·250 ± 1·299
Standard Deviation ...	19·698 ± 2·712	8·416 ± 1·159	6·124 ± 1·033	5·449 ± ·949
Coefficient of Variation ...	94·930 ± 6·325	49·505 ± 6·816	64·458 ± 10·869	41·121 ± 6·934
Range of Variation ...	1—56	9—42	4—24	8—21

Pearson, 1903, p. 203, notes 3 specimens, each with one Polian vesicle.

The mean number of Polian vesicles is 21, with a range of 1—56, in the adult and 10, with a range of 4—24, in the young. Ludwig, 1889–92, p. 115, gives the range as 1—10. The smallest Holothurid, *167*, has 10 Polian vesicles, and the smallest number any specimen has is 4. Thus *H. atra* shows a considerable difference from *H. floridana*, in which 74 °/₀ of the young have only one Polian vesicle. The mean greatest length increased from 13 mm. with a range of 8 mm.—21 mm. in the young, to 17 mm. with a range of 9 mm.—42 mm. in the adult.

J. Stone-canals and Madreporites.

The stone-canals and madreporites agree in location and form with *H. floridana* (p. 271). In *164* most of the madreporites are fused.

TABLE XXXVIII.

Stone-canals.

	ADULT; 12 SPECIMENS					YOUNG; 8 SPECIMENS				
	Number			Greatest Length mm.	Average Length mm.	Number			Greatest Length mm.	Average Length mm.
	Right	Left	Total			Right	Left	Total		
Mean	11·000 ±1·433	12·000 ± 1·769	24·084 ±2·933	9·500 ± ·744	7·117 ± ·428	8·250 ± ·789	6·375 ± ·394	13·250 ±1·155	4·750 ± ·426	4·325 ± ·623
Standard Deviation ...	7·360 ±1·013	9·083 ± 1·251	15·064 ±2·074	3·819 ± ·526	2·248 ± ·310	3·307 ± ·558	1·654 ± ·279	4·842 ± ·816	1·788 ± ·302	1·763 ± ·297
Coefficient of Variation	66·906 ±9·212	75·692 ±10·421	62·547 ±8·612	40·195 ±5·534	31·594 ±4·350	40·085 ±6·759	25·937 ±4·374	36·540 ±6·162	37·644 ±6·348	40·700 ±6·875
Range of Variation ...	4—27	7—43	15—70	5—16	4·5—11	1—13	2—8	8—21	2—8	1—7

In the adult the mean number of right canals is 11, with a range of 4—27 and of left canals, 12, with a range of 7—43. In the young the mean number of right canals is 8, with a range of 1—13 and of left canals 6, with a range of 2—8. With the mean number of right and left canals about the same in the adult, the left being slightly larger, what asymmetry is present is the opposite to that in *H. floridana.* In the young the asymmetry agrees with that of *H. floridana* but is less extensive. In the adult the mean total number of stone-canals is 24, with a range of 15—70, and in the young, 13, with a range of 8—21, not so great an age difference as shown in *H. floridana.* The mean total number in the adult is 54 °/₀ greater in *H. floridana.* Ludwig, 1889-92, p. 131, gives the range as 10—70 in *H. atra.*

The mean greatest length is 10 mm. with a range of 5 mm.—16 mm. in the adult, and 5 mm. with a range of 2 mm.—8 mm. in the young.

Thus the number of stone-canals and their length increase with age. The mean average length in the adult is 40 °/₀ greater than in *H. floridana.* Selenka, 1867, p. 326, observes that the stone-canals in specimens from the South Sea are about ½ longer, but not so many as in Florida specimens.

K. Gonads.

The gonads and gonaduct agree with those of *H. floridana.* Of the 12 adults 7 are male, 2 female, and 3 undifferentiated. Of the 8 young, 6 are undifferentiated and 2 have the gonads missing. This undifferentiated state is in harmony with the conclusion of Mitsukuri, 1902, p. 18, for *Stichopus japonicus,* that the first-year young and many of the second-year young have the gonads in an undeveloped condition.

L. Respiratory Trees.

Similar to *H. floridana.*

M. The Enteric Canal.

Gardiner, 1901–3, pp. 338—40, has studied the important function of *H. atra* and other forms, in reducing coral fragments to sand. The coarser fragments are retained in the gut, somewhat reduced in size, while the finer particles are swept along the gut, "presumably along its ciliated fold or groove."

N. Habitat.

INDIAN OCEAN, Lampert, 1885; MOZAMBIQUE, Bell, 1884; MADAGASCAR, *Nossibe,* Ludwig, 1883; ALDABRA IS., Voeltzkow, 1902; ZANZIBAR, Selenka, 1867; Ludwig, 1877, 1887, 1899; Lampert, 1885, 1896; *Tumbat I., Baui,* Lampert, 1896; AMIRANTE IS., Bell, 1884; *Darros I.,* Lampert, 1885, Bell; *Querimba (S.E. Coast, Africa),* Lampert, 1885; RED SEA, Semper, 1869; Ludwig, 1887 a; *Kossmann,* Lampert, 1885; *Djedda,* Lampert, 1885; Ludwig; LACCADIVE

AND MALDIVE IS., Gardiner, 1901–3; CEYLON, Bell, 1887; Ludwig, 1887; Thurston, 1890; *Gulf of Manaar, Trincomalee, Galle,* Pearson, 1903; BAY OF BENGAL, Bell, 1888; MERGUI ARCHIPELAGO, *Elphinstone I.,* Bell, 1886; NICOBAR IS., Semper, 1868; Lampert, 1885; EAST INDIA IS., Koehler, 1895; Koningsberger, 1904; SUMATRA, *Padang,* Ludwig; Lampert, 1885; JAVA, Selenka, 1867; Lampert, 1885; *Batavia,* Sluiter, 1887; *Sunda,* Lampert, 1885; *Saleh-Bai, Sebangkatan, Lombok, Lumu-Lumu, Seba (Savu), Kabala dua, Lucipara I., Haingsisi, Roma, Kangeang, Timor, Jedan,* Sluiter, 1901; *Timor I.,* Ludwig; Lampert, 1885; *Ambon,* Sluiter, 1894, 1895; CELEBES, Jäger, 1833; *Macassar,* Lampert, 1885; MOLUCCA OR SPICE IS., Semper, 1868; *Amboina,* Selenka, 1867; Semper, 1868; Lampert, 1885; Théel, 1886; *Batjan,* Semper, 1868; Lampert, 1885; *Ternate,* Marenzeller, 1900; *Pulo Tikul,* Lampert, 1885; *Pulu Tibul,* Ludwig; PHILIPPINE IS., Semper, 1868; *Cebu,* Lampert, 1885; *Mermaidstreet, Lucepara I.,* Lampert, 1889; AUSTRALIA, *Adelaide,* Lampert, 1885; *Great Barrier Reef,* Kent, 1893; PACIFIC OCEAN, CAROLINE IS., *Ualan I.,* Brandt, 1835 (Ludwig, 1881); RADACK CHAIN, Chamisso and Eysenhardt, 1821; GILBERT IS., *Paanopa (Ocean I.), Nauru (Pleasant I.),* Whitelegge, 1903; ELLICE IS., *Funafuti,* Whitelegge, 1897; Hedley, 1899; Bedford, 1899 a; *Rotuma,* Bedford, 1899 a; FIJI IS., Théel, 1886; LOYALTY IS., Bedford, 1899; SAMOAN IS. (NAVIGATOR IS.), Semper, 1868; *Viti,* Graeffe; TONGA IS., *Penope,* Théel, 1886; SOCIETY IS., Selenka, 1867; Lampert, 1885; *Tahiti,* Ludwig, 1883; HAWAIIAN IS., Selenka, 1867; Lampert, 1885; Fisher, 1907; CLIPPERTON I., Clark, 1902.

The specimens in this paper are from MOZAMBIQUE; ZANZIBAR; ARABIAN SEA; MARSHALL IS.; SAMOA, *Apia*; SOCIETY IS., *Tahiti*; HAWAIIAN IS., and GALAPAGOS IS. (the last in the collection of Dr H. L. Clark).

IV. SUMMARY.

A. Characters separating H. floridana Pourtalés (= H. mexicana Ludwig, H. africana Théel) from H. atra Jäger.

<table>
<tr><th></th><th colspan="4"><i>H. floridana</i> Pourtalés</th><th colspan="4"><i>H. atra</i> Jäger</th></tr>
<tr><td>Colouration</td><td colspan="4">The lighter tints of the browns prevail as the ground-colour. The markings are dots, spots, blotches, streaks or rings of the browns, creams, grays and whites.
Only 12 $^\circ/_\circ$ of the adult and 40 $^\circ/_\circ$ of the young have the entire body uniformly coloured. In all such cases the dark browns, usually seal and clove, are found. 60 $^\circ/_\circ$ of the adult and 13 $^\circ/_\circ$ of the young have the mid-dorsal region uniform in the browns. When the colours of this region are mixed the dark browns (seal, clove, Vandyke) predominate with some intermixture of creams and grays.
The lateral-dorsal regions are not half so uniform as the mid-dorsal and with a tendency to the lighter browns and creams.
The ventral region shows almost as much uniformity as the mid-dorsal in the adult, and almost three times as much in the young. The lighter browns and creams prevail in the adult and these colours together with the grays in the young.
In the adult the percentage of creams is doubled from mid- to lateral-dorsal and again from lateral-dorsal to ventral, thus gradually changing the colour from the dark brown back to the lighter belly.
Over the entire body the ends of the ambulacral appendages often arise from dark brown, or black, spots.
The young are more variegated but altogether these partly-coloured holothurians show much variation in the often fantastic combinations of the 25 tints of the browns, the 4 tints of the creams, the 9 tints of the grays, black and white.</td><td colspan="4">Mostly uniform seal-brown in both the adult and young. The ends of the appendages may be of a lighter tint like sepia.</td></tr>
<tr><td rowspan="2">Distribution of pedicels and papillae per sq. cm.</td><td colspan="2">Bivium</td><td colspan="2">Trivium</td><td colspan="2">Bivium</td><td colspan="2">Trivium</td></tr>
<tr><td>Adult 13</td><td>Young 21</td><td>Adult 25</td><td>Young 35</td><td>Adult 17</td><td>Young 31</td><td>Adult 45</td><td>Young 73</td></tr>
<tr><td>Number per sq. cm.</td><td colspan="4">1·6 as many in trivium as in bivium in adult and 1·4 in young.</td><td colspan="4">2·6 as many in trivium as in bivium in adult and 2·4 in young. 65 $^\circ/_\circ$ more appendages in <i>H. atra</i> than in <i>H. floridana</i>.</td></tr>
<tr><td>Skin</td><td colspan="4"><i>Warts</i>, each a heap of rosettes and perforated plates usually surmounted by a papilla. Found in 63 $^\circ/_\circ$ of adult, 98 $^\circ/_\circ$ of young, and in all larvae. In remaining 37 $^\circ/_\circ$ of adult and 2 $^\circ/_\circ$ of young warts probably present but not conspicuous and hence not seriated as such. In young warts most often in prominent right and left lateral rows.</td><td colspan="4"><i>Pits</i>, shallow, crater-like depressions (·15 mm. × ·1 mm.) in the body-wall, whose thickened, pigmented walls are separated from the surrounding tissue by crescentic clefts. Beneath each pit is a closed lacunar space.</td></tr>
</table>

SUMMARY—(*continued*).

	H. floridana Pourtalès	*H. atra* Jäger
Body-wall	Firm; mean thickness, 4 mm. in adult and 1·5 mm. in young. More variable in the adult but, in general, "thick skinned."	Flaccid; mean thickness 1·6 mm. in both adult and young. In general, "thin skinned."
Rosettes	Stellate, central rod short, branches swollen at ends. Growth-stages of the perforated plates.	Central rod somewhat elongated, branches more nearly at right angles. Longer and more delicate.
Perforated plates and rosettes with holes	(1) Developmental stages; *Type a*, 4 holes; *Type b*, 8 holes. (2) Developed plates; mean number of holes, 13 in bivium; 15 in trivium. With age, holes fill up with lime.	Of the statistical series of 300 rosettes and rosettes with holes, 2 had 3 holes, 4 had 2 holes and 19 had 1 hole. Rare variates may have more holes (up to 6) but such perforated plates are not like the developed perforated plates of *H. floridana*. Occasional elongated "Buttons" occur with 2 pairs of central holes and 1 distal hole at each end.
Average number of peripheral holes in discs of tables	5·2	3·7.
Number of rosettes and perforated plates per sq. cm.	5,000,000 to 12,000,000	50,000.
Pedicels and papillae in bivium	Large majority cylindrical and with suckers are pedicels. 1 out of 16, papillae.	Majority conical and without suckers are papillae.
Types of end-plates	In bivium, *A* (47 °/o), *B* (41 °/o), *C* (9 °/o), and *D* (1 °/o). In trivium, *A* (92 °/o), *B* (6 °/o) and *C* (2 °/o). Mean diameters of all types larger than in *H. atra*.	In bivium, *A* (·5 °/o), *B* (44 °/o), *C* (34 °/o), *D* (11 °/o) and *E* (4 °/o). In trivium, *A* (72 °/o), *B* (19 °/o), *C* (6 °/o), *D* (2 °/o) and *E* (2 °/o). Only 1 in bivium large enough to be placed in *Type A*.
Polian vesicles	Simple, or branched; solitary, or in tufts; mean number, in adult, 13, with range of 1—92. 74 °/o of young with 1 vesicle. Branching and formation of tufts due to growth.	Simple; mean number; in adult, 21, with range of 1—56; in young, 10, with range of 4—24.
Stone-canals Mean total number in adult	37, with range of 1—149. 54 °/o more than *H. atra*.	24, with range of 15—70.
Mean average length in adult	5 mm.	7 mm. 40 °/o longer than in *H. floridana*.

B. Characters Common to the Two Species.

Dimensions.—In both adult and young the standard deviation is least in the diameter, greater in the length and greatest in the volume. The relatively much larger standard deviation in the volume of the adult when compared with that of the young is to be expected because of the limited range of the latter.

Distribution of pedicels and papillae.—In both adult and young the standard deviation in the distribution of these appendages is considerably greater in the trivium.

Tentacles.—Mode, 20. As shown by the average standard deviation of ·7 in adult and young of *H. floridana* and of ·9 in *H. atra* the number of tentacles show but little variation when compared with most of the other characters.

The greater tendency in variation to less than the normal number, probably comes from the loss of tentacles by accident rather than from inherent congenital variation. It is therefore likely that the majority of the small and medium sized tentacles are stages in regeneration.

Variation in the location of the tentacles lying in the dorsal inter-radius with reference to the mesentery attachment is shown in about 20 °/₀ of the specimens.

The tentacular ampullae have branches only in the adult and hence the formation of such branches, when it occurs, comes with advancing age.

Pedicels and papillae defined.—The typical pedicel is cylindrical, with sucker, end-plate of *Type A* or *B*, sometimes with supporting rods different from those of the papilla.

The typical papilla is conical, without sucker, with end-plate of *Type D* or *E* and with supporting rods of its own kind.

The typical pedicels and papillae are connected by a group of appendages not definitely cylindrical or conical, with suckers either present, rudimentary or absent, having end-plates of *Type C* and with supporting rods either present or absent.

End-plates.—Standard deviation much the largest in *Type A*, decreasing relatively less and less with each succeeding type.

Supporting rods:—in papillae and tentacles; straight or curved rib-like rods with ends spinose, branched, or expanded, and with 1 to several holes.

In pedicels.—Straight, or slightly curved, rods with a hole in each expanded end. Sometimes with branched ends and several holes. Connecting links to the perforated plates of the body-wall may be found towards the base of the pedicel.

Tables.—The table developes from a short rod with forked ends. These ends divide and the recurved branches from either end grow together and fuse, forming the 4 larger primary holes of the centre of the disc. Then 4 smaller secondary, and often still smaller tertiary, peripheral holes are formed as the disc is completed. At the same time the vertical rods arise and then are bound together distally by transverse beams to form the spire and crown. At the last, from each corner, 3 teeth are developed, 2 horizontal diverging at right angles and the 3rd perpendicular to the plane of the others. The characters of the table show increasing variability in the following order, arranged according to the average of the standard deviations in adult and young, given after each character :—

Number of teeth on crown (1·1), number of spines on disc (1·4), diameter of hole in crown (2·1), number of peripheral holes in disc (2·3), diameter of crown, not including teeth (2·4), diameter of crown including teeth (5·5), diameter of disc (5·6), and height of table (9·4). The tables in the bivium have more peripheral holes, spines, and teeth, broader crown, larger crown-hole and longer teeth than in the trivium, although the difference in some of these characters is very small.

The average mean number of spines on the disc of the table in both bivium and trivium is ·6 in *H. floridana* and ·7 in *H. atra* while 80 °/o of the former and 82 °/o of the latter are without spines. Thus it is clearly apparent that the possession of spines is not a differential character for either species, and in connection with the much discussed variety *amboinensis* of Semper is of no importance whatever.

Rosettes.—Standard deviation slightly larger in the greater than in the smaller diameter.

Calcareous ring.—The pieces of the calcareous ring are more regular and delicate in the young. A variation of the radiale is found with notches toward the sides of the anterior margin.

Polian vesicles and stone-canals.—Increase in number and length with the growth of the animal.

C. Additional Characters of H. floridana.

Growth.—The embryo during the 5th day after fertilization and still within the vitelline membrane is ·33 mm. in length, ·28 mm. in diameter and ·0102 cm.^{3} in volume. In the 75th day it is 4 mm. in length, ·95 mm. in diameter and 1·4175 cm.^{3} in volume.

Adopting a volume of 50 cm.^{3} as the limit in size of the fully developed young, this group averages 7 cm. in length, 2 cm. in diameter and 13 cm.^{3} in volume.

The adult average 18 cm. in length, 5 cm. in diameter and 210 cm.^{3} in volume. The greatest length is 33 cm., the greatest diameter 8 cm., and the greatest volume 885 cm.^{3}

Tentacles.—20 °/o have less, and only 6 °/o more, than the mode of 20.

Development of tentacles.—In relation to their origin from the radial canals, the 4 primitive tentacles of the 4th day embryo are *d*1, left dorsal; *d*1 right ventral; *r*1, mid-ventral and *d*1, left ventral (cf. Scheme of Symmetry, Fig. A, Pl. V).

The remaining tentacles, so far as my series from the embryo extends, arise in the following order.—5th, *l*1, mid-ventral; 6th, *d*2, right ventral; 7th, *d*2, left ventral; 8th, *d*1, right dorsal; 9th and 10th, either *v*1 of right or left dorsal; 11th, *r*2, mid-ventral; 12th, *l*2, mid-ventral, and 13th, *d*2, left dorsal.

The tentacle ampullae have branches in 15 °/₀ of the specimens.

Development of pedicels and papillae.—The 1st pedicel buds from the posterior end of the mid-ventral radial canal in the 4th day. The next 3 arise from and *always to the left* of the mid-ventral radial canal and not until the 40th day does a pedicel appear *to the right* from this radial canal. The 1st pair of papillae appears on the 24th day ventrad from the anterior ends of the dorsal radial canals and will become warts. On the 30th day the 1st pair of pedicels appears from the lateral ventral radial canals. Gradually the number increases until the 75th day when there are 30 developed and 68 buds, mostly arranged in bilateral rows. The smallest of the fully-developed young has 77 developed pedicels and papillae in rows but later on the inter-radial regions of the adult show evenly distributed appendages.

Anal papillae.—In 5 groups in a majority of the specimens.

Spicules.—The rosettes are characteristic of the young and the perforated plates of the adult. The average of the standard deviations in number of holes in the dorsal and ventral rosettes with holes is 1·5.

Perforated plates.—Averages of the standard deviations of each character in bivium and trivium have the following order:—

a. *Developmental stages;*—number of holes (1·0), width (2·8) and length (3·0).

b. *Developed plates;*—Width (2·6), length (3·1) and number of holes (3·4).

Polian vesicles.—The standard deviation of the number of vesicles and branches is greater than that of the greatest length in the adult, and the reverse is true in the young. The variability in the number of vesicles and branches in the adult is 6 times that of the young and in the greatest length, twice that of the young.

Stone-canals.—The standard deviations of the various characters increase in the following order:—*Adult*, average length (1·7); greatest length (4·1); number, left (11·8), right (15·9), total (24·7): *Young*, average length (1·4), greatest length (2·2), number, left (2·5), right (4·0), total (6·0).

D. Additional Characters of H. atra.

Dimensions.—The young average 8 cm. in length, 2 cm. diameter and 20 cm.^{3} volume.

The adult average 16 cm. in length, 5 cm. in diameter and 170 cm.^{3} in volume. The greatest length is 33 cm. The greatest diameter 8 cm. and the greatest volume 538 cm.^{3}

Tentacles.—35 °/₀ have less and only 5 °/₀ more than the mode of 20.

In one case, the largest adult, the tentacular ampullae have 25 branches.

Anal papillae.—Indefinitely distributed in a majority of the specimens.

Supporting rosettes or plates.—Are found in the wall of the sucker, near the end-plate of the pedicel.

Rosettes with holes.—Average standard deviation in number of holes ·5.

Polian vesicles.—In the adult the standard deviation of the number of vesicles and branches (19·6) is over twice that of the greatest length (8·4). In the young (6·1) it is slightly greater than that of the greatest length (5·4).

Stone-canals.—The standard deviations of the various characters increase in the following order:—*Adult*, number, right (1·0), average length (2·2), greatest length (3·8), number, left (9·0), total (15·0):—*Young*, number, left (1·6), average length (1·7), greatest length (1·7), number, right (3·3), total (4·8).

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EXPLANATION OF PLATES.

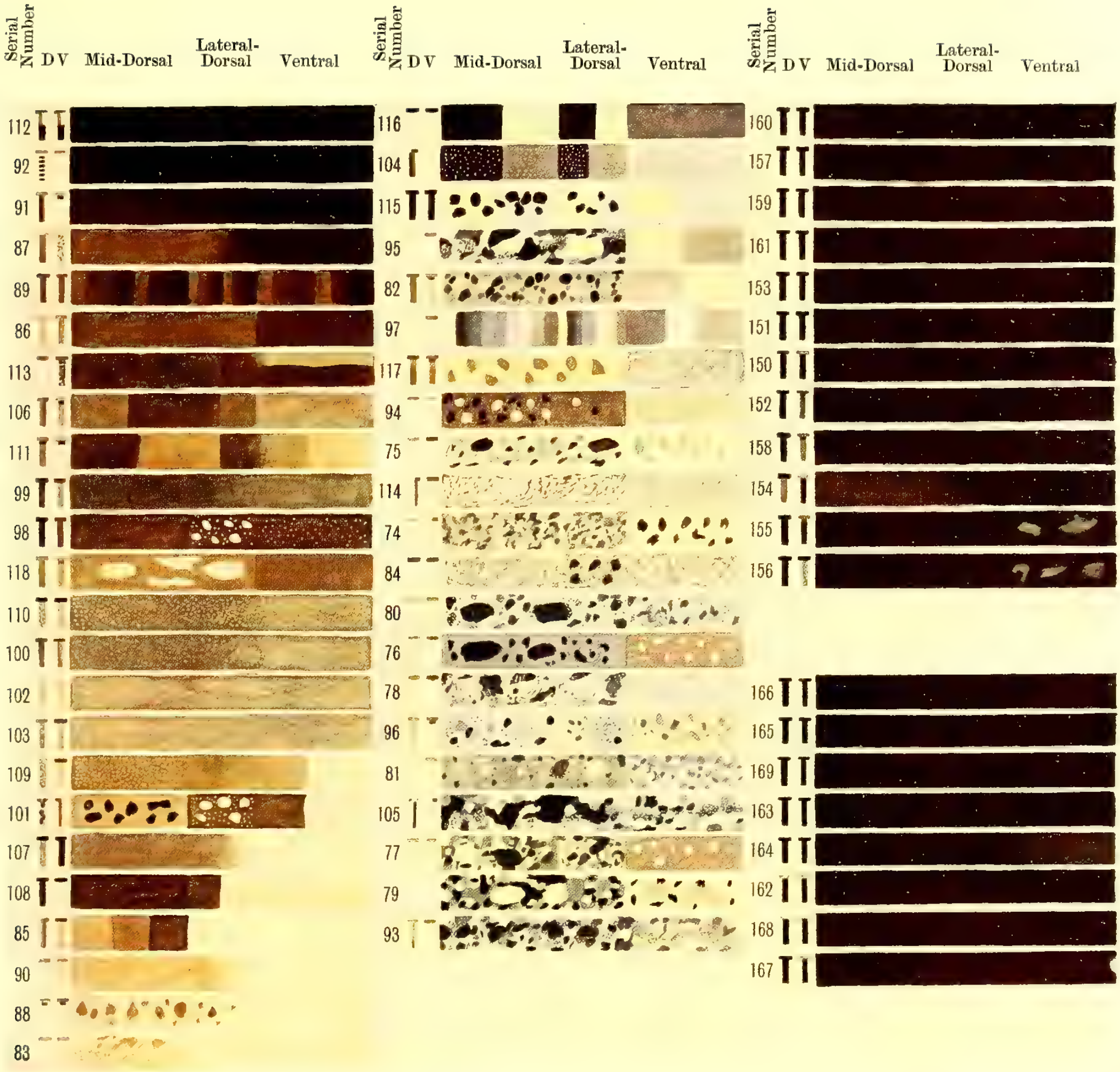
Plate I. Colour variation in the young of *H. floridana* Pourtalès (112—93) and of the adult (160—156) and young (166—167) of *H. atra* Jäger. The ambulacral appendages (pedicels and papillae) and the regions of the body are represented in a diagrammatic form for each individual of the statistical series as numbered in the column to the left. The appendages under D are dorsal and under V, ventral. The stalk and usually expanded terminal end of each appendage and the various regions of the surface of the body show the average colouration and its distribution for the respective parts. The colours, "browns," "creams," "grays," black and white, are given as they occur in dots, spots and blotches upon the general background, or else as uniform for the whole body, or its different regions. The plate does not always give exactly the colour effects of the original water-colours as described in the text. The predominant tint in 160—167 is seal-brown rather than violet-brown. The violet tone also has modified the grays and creams in 112—93. In 112, 92, and the ventral region of 91, the tint should be clove-brown.

Plate II. Colour variation in the adult of *Holothuria floridana* Pourtalès. General explanation as given for Plate I. The original colours resemble those in Plate I as qualified in the above explanation. The colour values are not fully reproduced in the half-tone for the dark shades are browns that range from seal, Vandyke, sepia, and other tints, to clove-brown and black instead of having the uniformity represented.

Plate III. Papilla, pedicel and their calcareous spicules.
Figs. 10, 11, 13, 17—22 from *H. floridana* ; 1—9, 12, 14—16 from *H. atra*.
Figs. 1, 3, 5—13 dorsal ; 2, 4, 14—22 ventral.
Figs. 1—9, × $55\frac{1}{3}$; 10—22, × 260.
Fig. 1. Papilla with supporting rods and *type E* end-plate.
Fig. 2. Pedicel with supporting rods, sucker, and *type A* end-plate in profile.
Fig. 3. *Type A*, end-plate.
Fig. 4. *Type A* end-plate with larger holes toward the centre.
Fig. 5. *Type B* end-plate.
Fig. 6. *Type C* end-plate.
Fig. 7. *Type C* end-plate with larger, irregular holes.
Fig. 8. *Type D* end-plate.
Fig. 9. *Type E* end-plate.
Figs. 10—12. Variation types of dorsal supporting rods.
Fig. 10. Nearly straight with ends spinous.
Fig. 11. Arcuate with spinous ends branched.
Fig. 12. Expanded ends spinous, branched and perforated.
Fig. 13. Rare dorsal supporting rosette.
Fig. 14. Ventral supporting plate.
Figs. 15, 16. Ventral supporting rosettes with broadly branched perforated ends.
Figs. 17—22. Series of ventral supporting rods, nearly straight with more or less expanded, branched and perforated ends (Figs. 20—22) leading through connecting links (Figs. 18, 19) to the perforated plate (Fig. 17) characteristic of the body-wall.

Plate IV. Calcareous spicules of the body-wall ; their form, size, development and variation.
Figs. 28—45, 47, 49, 50, 53, 55—60, 62—66, 68—70, 73, from *H. floridana* ; 23—27 f., 46, 48, 51, 52, 54, 61, 67, 71, 72, 74, from *H. atra*.
Figs. 24, 28—36, 38, 42—45, 47—51, 53—66, 68—70, 73, dorsal ; 23, 25—27 f., 37, 39—41, 46, 52, 67, 71, 72, 74, ventral. All figures × 260.
Figs. 23—26 rosettes ; 26—27 f. rosettes with holes and perforated plates of *H. atra*.
Figs. 28—33, 35 rosettes and developmental stages of perforated plates ; 34, 36—41 perforated plates of *H. floridana* ; 37, developmental *Type a* ; 38, developmental *Type b* ; 38a, *Type b*, incomplete

Plate I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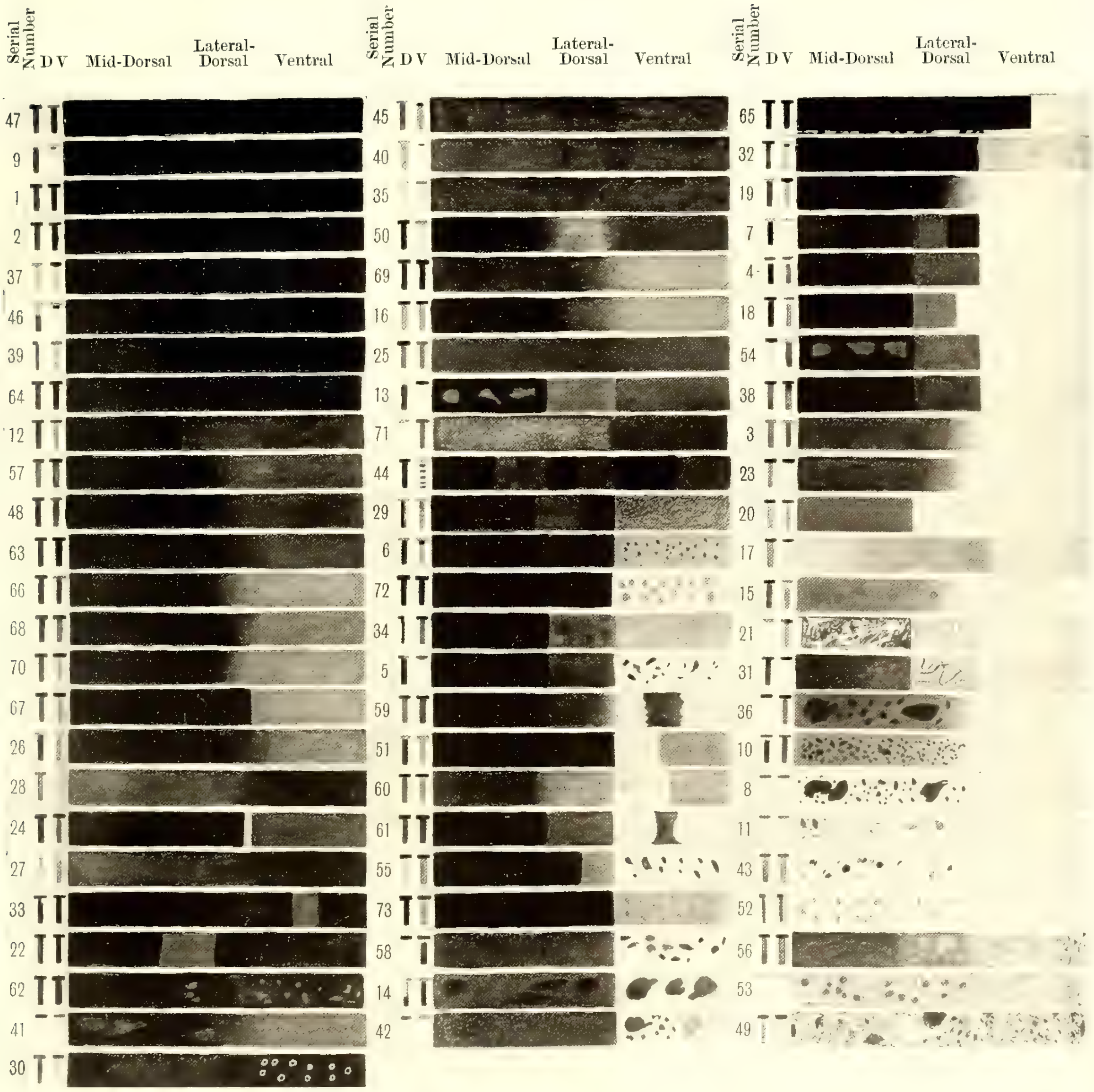
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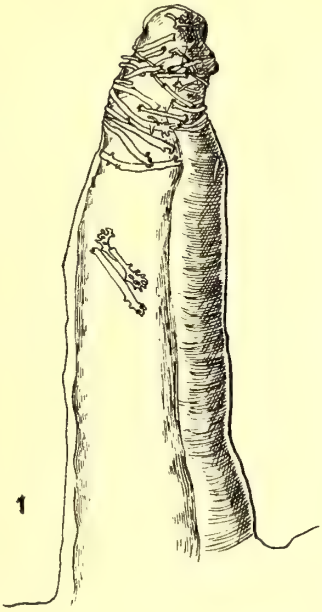
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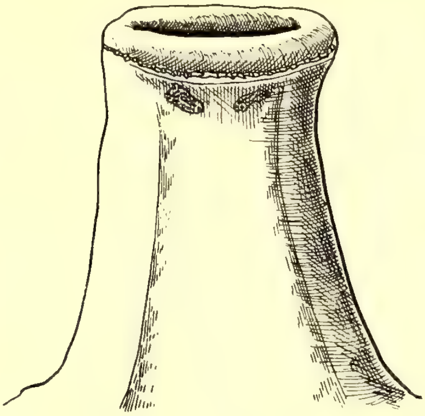
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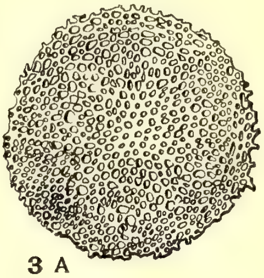
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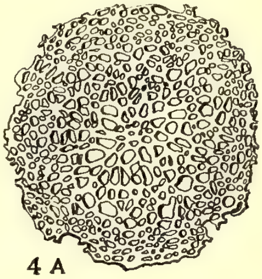
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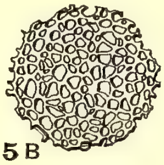
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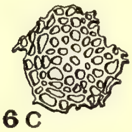
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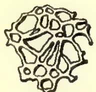
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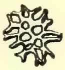
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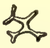
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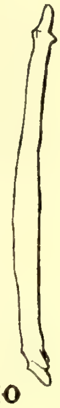
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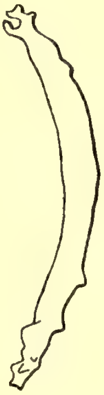
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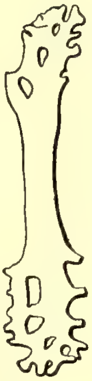
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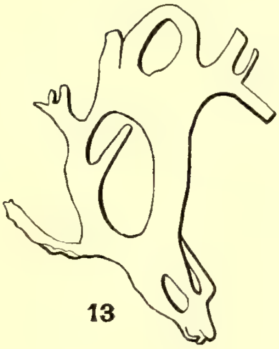
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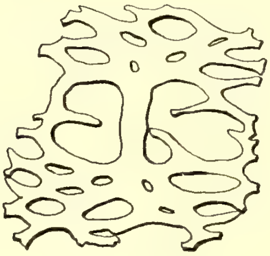
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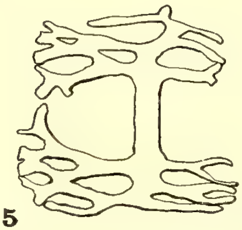
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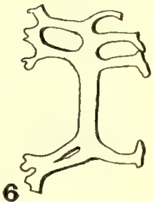
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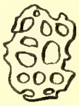
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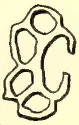
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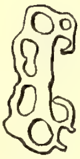
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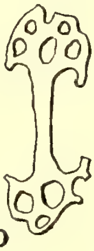
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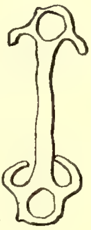
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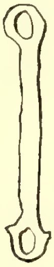
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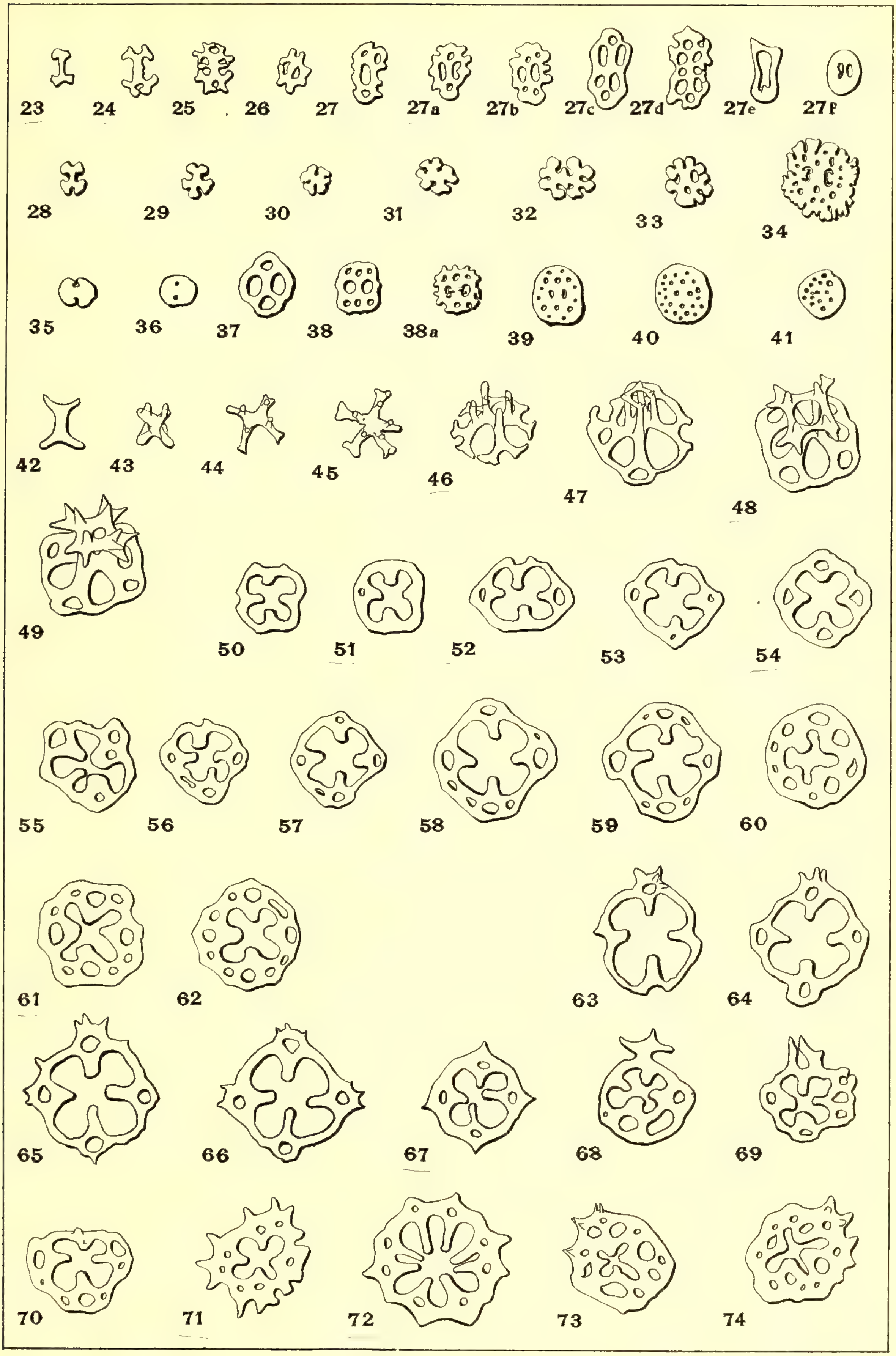

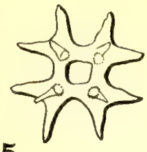
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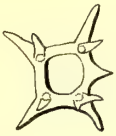
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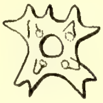
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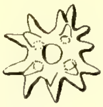
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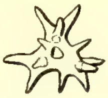
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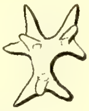
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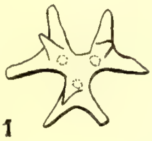
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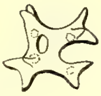
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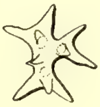
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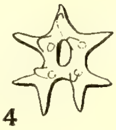
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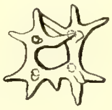
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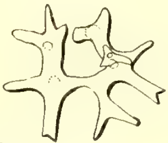
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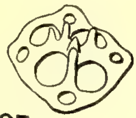
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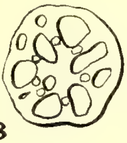
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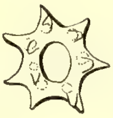
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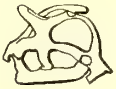
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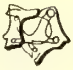
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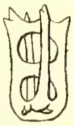
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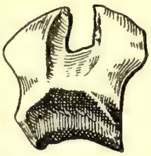
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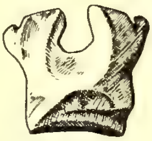
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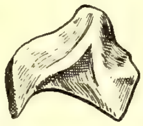
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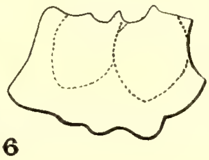
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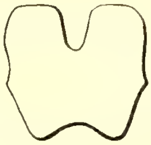
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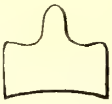
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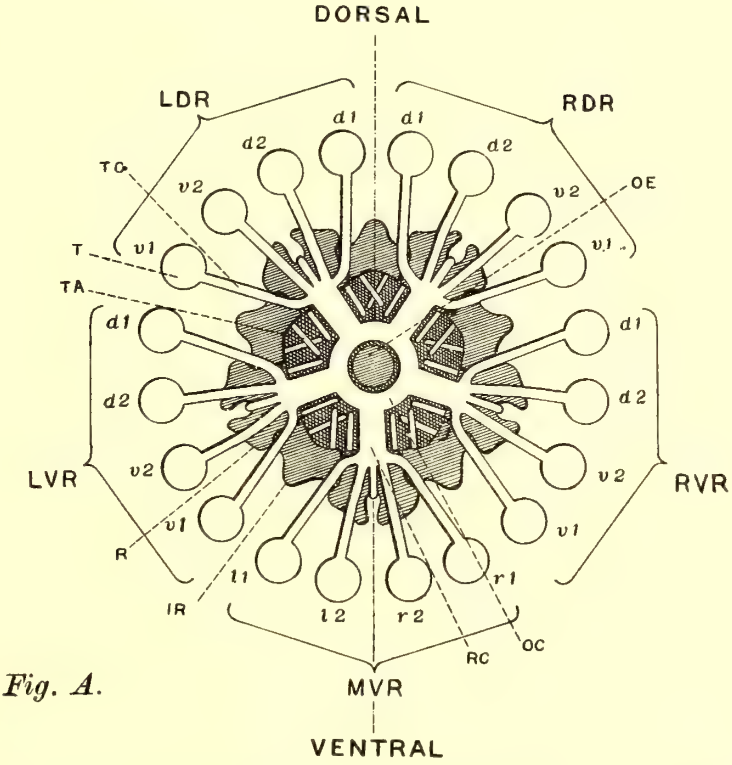
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LVR
v2
v2
RVR
v1
v1
R
l1
r1
IR
l2
r2
OC
RC
MVR
VENTRAL

Fig. A.

and in process of growth ; 36, 39—41, completely developed plates, the holes filling with lime until in 41 over ⅔ of the holes have become filled to pits (indicated by shading) ; 34, incomplete plate of large size. In 34, 39, 40 the basic developmental *Types a* and *b* may be noted surrounded with additional peripheral holes.

Figs. 42—49 illustrate the development of the table.

Fig. 42. Rod with forked end, Anlage of disc.

Fig. 43. Appearance of the 4 vertical rods.

Fig. 44. Ends of the 4 prongs begin forking.

Fig. 45. Variate with 5 prongs and 5 vertical rods.

Fig. 46. Formation of primary and peripheral holes of disc and growth of vertical rods.

Fig. 47. The 4 primary and 2 of the secondary holes completed ; joining of vertical rods by transverse beams to form crown ; appearance of teeth.

Fig. 48. Nearly developed table.

Fig. 49. Fully developed table.

Figs. 50—62. Series of disc variates. To show the feature of the disc each is drawn with the vertical rods bearing the crown removed at their bases. Figs. 50—54 have the 4 primary holes indicated with developing secondary holes as follows : 50, none ; 51, 1 ; 52, 2 ; 53, 3 ; 54, 4.

Figs. 55—62 show variation in the number of peripheral holes (secondary and tertiary) from 4—11.

Figs. 63—74. Series of discs (drawn as above) showing variation in the number (1—10), form and size of spines, accompanied by a modal distribution of holes (64—67) or by an abnormal number and distribution of holes (63, 68—74). In 72, with a nearly circular disc, there are 8 vertical rods with a secondary hole for each rod.

Plate V. Calcareous spicules of the body-wall and the pieces of the calcareous ring.

Figs. 77, 78, 80, 83, 85, 87, 90—98 from *H. floridana* ; 75, 76, 79, 81, 82, 86, 88, 89 from *H. atra*.

Figs. 77, 78, 80, 83—85, 87, 90—92 dorsal ; 75, 76, 79, 82, 86, 88, 89 ventral.

Figs. 75—92, ×260 ; Figs. 93—96, ×2⅓; 97, 98, ×9⅓.

Figs. 75—86. Series of crown variates. The underlying vertical rods are indicated by dotted outlines. Fig. 75, normal type with 12 teeth ; 76, 2 teeth at each of 3 corners, 3 at the 4th and 1 on a transverse bar ; 77, extra tooth on a transverse bar ; 78, 3 extra teeth on transverse bars ; 79, triangular variate with extra tooth on each of 3 transverse bars ; 80, incomplete crown, 1 corner lacking ; 81, triangular variate without central hole ; 82—84, abnormal variates ; 85, incomplete crown from the failure to fuse of the two processes which would normally make a transverse bar ; 86, incomplete crown with some teeth lacking, 2 bifid and 1 extra vertical rod.

Fig. 87. Complete disc, 5 vertical rods and no crown.

Fig. 88. Disc and 89 crown, of table with 7 vertical rods.

Fig. 90. Disc and 91 crown, of abnormal variate.

Fig. 92. Reduced table with only central part of disc and the spire present.

Figs. 93—96 from calcareous ring of the adult.

Fig. 93. Radiale, usual form.

Fig. 94. Radiale, with anterior border notched toward the sides.

Fig. 95. Inter-radiale.

Fig. 96. Fused ventral and left ventral radialia, the intervening left ventral inter-radiale included in the compound piece.

Figs. 97, 98. More regular and delicate pieces of the calcareous ring of the young.

Fig. 97. Radiale.

Fig. 98. Inter-radiale.

Fig. A. See for explanation p. 248.

PROBABLE ERROR OF A CORRELATION COEFFICIENT.

By STUDENT.

At the discussion of Mr R. H. Hooker's recent paper "The correlation of the weather and crops" (*Journ. Royal Stat. Soc.* 1907) Dr Shaw made an enquiry as to the significance of correlation coefficients derived from small numbers of cases.

His question was answered by Messrs Yule and Hooker and Professor Edgeworth, all of whom considered that Mr Hooker was probably safe in taking ·50 as his limit of significance for a sample of 21. They did not, however, answer Dr Shaw's question in any more general way. Now Mr Hooker is not the only statistician who is forced to work with very small samples, and until Dr Shaw's question has been properly answered the results of such investigations lack the criterion which would enable us to make full use of them. The present paper, which is an account of some sampling experiments, has two objects: (1) to throw some light by empirical methods on the problem itself, (2) to endeavour to interest mathematicians who have both time and ability to solve it.

Before proceeding further, it may be as well to state the problem which occurs in practice, for it is often confused with other allied questions.

A random sample has been obtained from an indefinitely large* population and r† calculated between two variable characters of the individuals composing the sample. We require the probability that R for the population from which the sample is drawn shall lie between any given limits.

It is clear that in order to solve this problem we must know two things: (1) the distribution of values of r derived from samples of a population which has a given

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* Note that the indefinitely large population need not actually exist. In Mr Hooker's case his sample was 21 years of farming under modern conditions in England, and included all the years about which information was obtainable. Probably it could not actually have been made much larger without loss of homogeneity, due to the mixing with farming under conditions not modern; but one can imagine the population indefinitely increased and the 21 years to be a sample from this.

† Throughout the rest of this paper "r" is written for the correlation coefficient of a sample and R for correlation coefficient of a population.

R, and (2) the *à priori* probability that R for the population lies between any given limits. Now (2) can hardly ever be known, so that some arbitrary assumption must in general be made; when we know (1) it will be time enough to discuss what will be the best assumption to make, but meanwhile I may suggest two more or less obvious distributions. The first is that any value is equally likely between $+1$ and -1, and the second that the probability that x is the value is proportional to $1-x^2$: this I think is more in accordance with ordinary experience: the distribution of *à priori* distribution would then be expressed by the equation $y=\frac{3}{4}(1-x^2)$.

But whatever assumption be made, it will be necessary to know (1), so that the solution really turns on the distribution of r for samples drawn from the same population. Now this has been determined for *large* samples with as much accuracy as is required, for Pearson and Filon (*Phil. Trans.* Vol. 191 A, p. 229 *et seq.*) showed that the standard deviation is $\frac{1-r^2}{\sqrt{n}}$ and of course for large samples the distribution is sure to be practically normal unless r is very close to unity. But their method involves approximations which are not legitimate when the sample is small. Besides this the distribution is not then normal, so that even if we had the standard deviation a great deal would still remain unknown.

In order to throw some light on this question I took a correlation table* containing 3000 cases of stature and length of left middle finger of criminals, and proceeded to draw samples of four from this population†. This gave me 750 values of r for a population whose real correlation was ·66. By taking the statures of one sample with the middle finger lengths of the next sample I was enabled to get 750 values of r for a population whose real correlation was zero. Next I combined each of the samples of four with the tenth sample before it and with the tenth sample after it, thus obtaining two sets of 750‡ values from samples of 8, with real correlation ·66 and zero.

Besides this empirical work it is possible to calculate *à priori* the distribution for samples of two as follows.

For clearly the only values possible are $+1$ and -1, since two points must always lie on the regression line which joins them§.

Next consider the correlation between the difference between the values of one character in two successive individuals, and the difference between the values of the other character in the same individuals. It is well known to be the same as that between the values themselves, if the individuals be in random order.

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* *Biometrika*, Vol. I. p. 219. W. R. Macdonnell. † *Biometrika*, Vol. VI. p. 13. Student.

‡ Not strictly independent, but practically sufficiently nearly so. This method was adopted in order to save arithmetic.

§ There are of course indeterminate cases when the values are the same for one character, but they become rarer as we decrease the unit of grouping until with an infinitesimal unit of grouping the statement in the text is true.

Also, if an indefinitely large number of such differences be taken, it is clear that the means of the distributions will have the value zero. Hence, if the correlation be determined from a fourfold division through zero we can apply Mr Sheppard's* result that if A and B be the numbers in the large and the small divisions of the table respectively $\cos\frac{\pi B}{A+B}=R$, where R is the correlation of the original system.

But if a pair of individuals whose difference falls in either of the small divisions be considered to be a random sample of 2, their r will be found to be -1, while that of a pair whose difference falls in one of the large divisions is $+1$. Hence the distribution of r for samples of 2 is AN at $+1$, and BN at -1, where $A+B=1$, and $B=\frac{\cos^{-1}R}{\pi}$.

When $R=0$, there is of course even division, half the values being $+1$, and half -1; when $R=\cdot 66$, $B=\frac{\cos^{-1}\cdot 66}{\pi}=\cdot 271$, therefore $A=\cdot 729$, and the mean is at $\cdot 729-\cdot 271=\cdot 458$. The S.D. $=\sqrt{1-(\cdot 458)^2}=\cdot 889$. It is noteworthy that the mean value is considerably less than R.

I have dealt with the cases of samples of 2 at some length, because it is possible that this limiting value of the distribution with its mean of $\frac{2}{\pi}\sin^{-1}R$ and its second moment coefficient of $1-\left(\frac{2}{\pi}\sin^{-1}R\right)^2$ may furnish a clue to the distribution when n is greater than 2.

Besides these series, I have another shorter one of 100 values of r from samples of 30, when the real value is ·66. The distributions of the various trials are given in the table.

Several peculiarities will be noticed which are due to the effects of grouping, particularly in the samples of 4. Firstly, there is a lump at zero; with such small numbers zero is not an uncommon value of the product moment and then, whatever the values of the standard deviations, $r=0$.

Next there are five indeterminate cases in each of the distributions for samples of 4. These are due to the whole sample falling in the same group for one variable. In such a case, both the Standard Deviation and the product moment vanish and r is indeterminate.

Lastly, with such small samples one cannot use Sheppard's corrections for the Standard Deviations, as r often becomes greater than unity. So I did not use the corrections except in the case of the samples of 30, yet on the whole the values of the Standard Deviations are no doubt too large. This does not much affect the values of r in the neighbourhood of zero, but there is a tendency for larger values

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* *Phil. Trans.* A. Vol. CXCII. p. 141.

Distribution of Correlation Coefficients.

Scale	−1·00 −·98	−·97 −·93	−·92 −·88	−·87 −·83	−·82 −·78	−·77 −·73	−·72 −·68	−·67 −·63	−·62 −·58	−·57 −·53	−·52 −·48	−·47 −·43	−·42 −·38	−·37 −·33	−·32 −·28	−·27 −·23	−·22 −·18	−·17 −·13	−·12 −·08	−·07 −·03	−·02 +·02
No correlation, Samples of 4*	8	17	16	23	13	23	9½	19½	19	17	23	18½	25½	15	22	22	19	19½	23½	15	30
No correlation, Samples of 8	1	—	—	1	7	10	10	15	14	15	18	24	18	27	36	33	43	45	26½	26½	34
Correlation of ·66 Samples of 4†	3	3½	2½	2	2	8	3½	1½	5	9	8	7	3	1	4	10	5	5	3	6	16
Correlation of ·66 Samples of 8	—	—	—	—	—	—	—	—	—	2	—	2	—	3	—	3	6	4	3	4	5

Scale	+·03 +·07	+·08 +·12	+·13 +·17	+·18 +·22	+·23 +·27	+·28 +·32	+·33 +·37	+·38 +·42	+·43 +·47	+·48 +·52	+·53 +·57	+·58 +·62	+·63 +·67	+·68 +·72	+·73 +·77	+·78 +·82	+·83 +·87	+·88 +·92	+·93 +·97	+·98 +1·00
No correlation, Samples of 4*	18	14	22	22	22½	24	13½	17	23	24	24½	9½	17½	17½	11½	12½	9	22½	13½	9
No correlation, Samples of 8	42½	27½	34	23½	36½	33½	28½	19	24	22	15	13½	9	2½	7	5	3	—	—	—
Correlation of ·66 Samples of 4†	4	7	9	11	8	14	11	20½	18	30	23½	27	33½	45½	39½	41	80½	64	91	59
Correlation of ·66 Samples of 8	7	7	5	11	17	20	17	22	34	46½	44½	61	59	66½	56½	80½	60	66	33½	4

Scale	·26 to ·28	·29 to ·31	·32 to ·34	·35 to ·37	·38 to ·40	·41 to ·43	·44 to ·46	·47 to ·49	·50 to ·52	·53 to ·55	·56 to ·58	·59 to ·61	·62 to ·64	·65 to ·67	·68 to ·70	·71 to ·73	·74 to ·76	·77 to ·79	·80 to ·82	·83 to ·85
Distribution with samples of 30	1	—	—	1	—	1	—	1	6	4	5	9	12	10	15	12	7	10	5	1

* There are five indeterminate cases so that the total is 745, while there are 750 in the other two distributions.

† The moment coefficients of this distribution were actually calculated from a different grouping as below:

−1·00 −·95	−·94 −·90	−·89 −·85	−·84 −·80	−·79 −·75	−·74 −·70	−·69 −·65	−·64 −·60	−·59 −·55	−·54 −·50	−·49 −·45	−·44 −·40	−·39 −·35	−·34 −·30	−·29 −·25	−·24 −·20	−·19 −·15	−·14 −·10	−·09 −·05	−·04 −·00
5	4	2	2	6	4	3	4	7	9	7	5	1	2	6	7	7	5	4	18

+·01 +·05	+·06 +·10	+·11 +·15	+·16 +·20	+·21 +·25	+·26 +·30	+·31 +·35	+·36 +·40	+·41 +·45	+·46 +·50	+·51 +·55	+·56 +·60	+·61 +·65	+·66 +·70	+·71 +·75	+·76 +·80	+·81 +·85	+·86 +·90	+·91 +·95	+·96 +1·00
2	5	11	8	12	12½	7½	17	21	24	20	35	31	35	50	34	58½	78	77	98½

to come too low, so that there is a deficiency of cases towards 1 and -1. This introduces an error into the Standard Deviation of all the series to some extent, but of course the mean is unaltered when there is no correlation. The series for samples of 4 are affected more than those from samples of 8, as the mean Standard Deviation of samples of 4 is the smaller, so that the unit of grouping is comparatively larger.

The moment coefficients of the five distributions were determined, and the following values found*:—

	Mean	S.D.	μ_2	μ_3	μ_4	β_1	β_2
Samples of 4 ($r=0$)	—	·5512	·3038	—	·1768	—	1·918
Samples of 8 ($r=0$)	—	·3731	·1392	—	·0454	—	2·336
Samples of 4 ($r=·66$)	·5609	·4680	·2190	$-$·1570	·2152	2·245	4·489
Samples of 8 ($r=·66$)	.6139	·2684	·07202	$-$·02634	·02714	1·857	5·232
Samples of 30 ($r=·66$)	·661	·1001	·01003	$-$·000882	·000461	·7713	4·580

Considering first the "no correlation" distributions I attempted to fit a Pearson curve to the first of them. As might be expected, the range proved limited and as symmetry had been assumed in calculating the moments, a Type II curve resulted. The equation was $y=y_0\left(1-\frac{x^2}{1·076}\right)^{·272}$, the range of which is 2·074.

Now the real range is clearly 2, and only a very small alteration in β_2 is required to make the value of the index zero. Consequently the equation $y=y_0(1-x^2)^0$ was suggested. This means an even distribution of r between 1 and -1, with S.D. $= ·5774 \pm ·010$ vice ·5512 actual, $\mu_2 = ·3333 \pm ·0116$ vice ·3038, $\mu_4 = ·2000 \pm ·016$ vice ·1768 and $\beta_2 = 1·800 \pm ·12$ vice 1·918, all values as close as could perhaps be expected considering that the grouping must make both μ_2 and μ_4 too low.

Working from $y=y_0(1-x^2)^0$ for samples of 4 I guessed the formula $y=y_0(1-x^2)^{\frac{n-4}{2}}$ and proceeded to calculate the moments.

By using the transformation $x=\sin\theta$ we get $y=y_0\cos^{n-4}\theta$,

$$dx=\cos\theta\, d\theta,$$

$$2\int_0^1 y\,dx = 2y_0\int_0^{\frac{\pi}{2}}\cos^{n-3}\theta\, d\theta,$$

$$2\int_0^1 x^2 y\,dx = 2y_0\int_0^{\frac{\pi}{2}}\cos^{n-3}\theta\, d\theta - 2y_0\int_0^{\frac{\pi}{2}}\cos^{n-1}\theta\, d\theta,$$

and so on.

Whence

$$\mu_2=\frac{1}{n-1},\qquad \mu_4=\frac{3}{(n-1)(n+1)},\qquad \beta_2=\frac{3(n-1)}{n+1}=3-\frac{6}{n+1}.$$

---

* In the cases of no correlation the moments were taken about zero, the known centroid of the distribution.

Putting $n=8$ we get the equation $y=y_0(1-x^2)^2$ and

$$\begin{array}{llll}
\mu_2=\frac{1}{7}={\cdot}1429\pm{\cdot}0050 & \text{instead of actual} & & {\cdot}1392, \\
\mu_4=\frac{1}{21}={\cdot}0476\pm{\cdot}0038 & ,, & ,, & {\cdot}0454, \\
\sigma={\cdot}3780\pm{\cdot}0066 & ,, & ,, & {\cdot}3731, \\
\beta_2=3-\frac{6}{9}=2{\cdot}333\pm{\cdot}012 & ,, & ,, & 2{\cdot}336.
\end{array}$$

The equation calculated from the actual moments is $y=y_0\left(1-\frac{x^2}{{\cdot}9802}\right)^{2{\cdot}021}$ whence the calculated range is 1·98, whereas it is known to be 2.

The following tables compare the actual distributions with those calculated from the equations.

Distribution of r from samples of 4 compared with the equation $y=\frac{745}{2}(1-x^2)^0$.

	-1 to $-{\cdot}825$	$-{\cdot}825$ to $-{\cdot}675$	$-{\cdot}675$ to $-{\cdot}525$	$-{\cdot}525$ to $-{\cdot}375$	$-{\cdot}375$ to $-{\cdot}225$	$-{\cdot}225$ to $-{\cdot}075$	$-{\cdot}075$ to $+{\cdot}075$	$+{\cdot}075$ to $+{\cdot}225$	$+{\cdot}225$ to $+{\cdot}375$	$+{\cdot}375$ to $+{\cdot}525$	$+{\cdot}525$ to $+{\cdot}675$	$+{\cdot}675$ to $+{\cdot}825$	$+{\cdot}825$ to $+1$
Actual ...	64	$45\frac{1}{2}$	$55\frac{1}{2}$	67	59	62	63	58	60	64	$51\frac{1}{2}$	$41\frac{1}{2}$	54
Calculated	65	56	56	56	56	56	56	56	56	56	56	56	65
Difference	-1	$-10\frac{1}{2}$	$-\frac{1}{2}$	$+11$	$+3$	$+6$	$+7$	$+2$	$+4$	$+8$	$-4\frac{1}{2}$	$-14\frac{1}{2}$	-11

From this we get $\chi^2=13{\cdot}30$, $P={\cdot}34$. It will however be noticed that the grouping has caused all the middle compartments to contain more than the calculated, as pointed out above.

Distribution of r from samples of 8 compared with the equation $y=\frac{750\times 15}{16}(1-x^2)^2$.

	-1 to $-{\cdot}825$	$-{\cdot}825$ to $-{\cdot}675$	$-{\cdot}675$ to $-{\cdot}525$	$-{\cdot}525$ to $-{\cdot}375$	$-{\cdot}375$ to $-{\cdot}225$	$-{\cdot}225$ to $-{\cdot}075$	$-{\cdot}075$ to $+{\cdot}075$	$+{\cdot}075$ to $+{\cdot}225$	$+{\cdot}225$ to $+{\cdot}375$	$+{\cdot}375$ to $+{\cdot}525$	$+{\cdot}525$ to $+{\cdot}675$	$+{\cdot}675$ to $+{\cdot}825$	$+{\cdot}825$ to $+1$
Actual ...	2	27	44	60	96	$114\frac{1}{2}$	103	85	$98\frac{1}{2}$	65	$37\frac{1}{2}$	$14\frac{1}{2}$	3
Calculated	$4\frac{1}{2}$	$20\frac{1}{2}$	43	67	87	$100\frac{1}{2}$	105	$100\frac{1}{2}$	87	67	43	$20\frac{1}{2}$	$4\frac{1}{2}$
Difference	$-2\frac{1}{2}$	$+6\frac{1}{2}$	$+1$	-7	$+9$	$+14$	-2	$-15\frac{1}{2}$	$+11\frac{1}{2}$	-2	$-5\frac{1}{2}$	-6	$-1\frac{1}{2}$

whence $\chi^2=13{\cdot}94$, $P={\cdot}30$.

In this case the grouping has had less influence and the largest contributions to χ^2 (in the second, sixth, eighth, and twelfth compartments) are due to differences of opposite sign on opposite sides, and may therefore be supposed to be entirely due to random sampling.

My equation then fits the two series of empirical results about as well as could be expected. I will now show that it is in accordance with the two theoretical cases n "large" and $n=2$, for $\sigma=\frac{1}{\sqrt{n-1}}$ which approximates sufficiently closely to Pearson and Filon's $\frac{1-r^2}{\sqrt{n}}$ when $r=0$ and n is large. Also when n is large β_2 becomes 3 and the distribution is normal.

And if $n=2$, the equation becomes $y=y_0(1-x^2)^{-1}$* where

$$y_0=\frac{N}{2\int_0^1(1-x^2)^{-1}dx}.$$

Put $x=\sin\theta$. Then $dx=\cos\theta d\theta$,

$$y_0=\frac{N}{2}\Big/\int_0^{\frac{\pi}{2}}\sec\theta d\theta=\frac{N}{2}\Big/\infty=0,$$

i.e. there is no frequency except where $(1-x^2)^{-1}$ is infinite, all the frequency is equally divided between $x=1$ and $x=-1$ which we know to be actually the case.

Consequently I believe that the equation $y=y_0(1-x^2)^{\frac{n-4}{2}}$ probably represents the theoretical distribution of r when samples of n are drawn from a normally distributed population with no correlation. Even if it does not do so, I am sure that it will give a close approximation to it.

Let us consider Mr Hooker's limit of ·50 in the light of this equation. For 21 cases the equation becomes $\left.\begin{array}{l}x=\sin\theta\\ y=y_0\cos^{17}\theta\end{array}\right\}$ and the proportion of the area lying beyond $x=\pm\cdot50$ will be

$$\frac{\int_{\theta=\sin^{-1}\cdot50}^{\theta=\frac{\pi}{2}}\cos^{18}\theta d\theta}{\int_0^{\frac{\pi}{2}}\cos^{18}\theta d\theta}.$$

I find this to be ·02099, or we may expect to find one case in 50 occurring outside the limits $\pm\cdot50$ when there is no correlation and the sample numbers 21.

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* If a Pearson curve be fitted to the distribution whose moment coefficients are $\mu_2=1=\mu_4$ and $\mu_3=0$ we have $\beta_2=1$, $\beta_1=0$, hence the curve must be of Type II. and the equation is given by

$$y=y_0\left(1-\frac{x^2}{a^2}\right)^m \text{ where } a^2=\frac{2\mu_2\beta_2}{3-\beta_2}=1 \text{ and } m=\frac{5\beta_2-9}{2(3-\beta_2)} \text{ or } y=y_0(1-x^2)^{-1},$$

agreeing with the general formula.

When however there is correlation, I cannot suggest an equation which will accord with the facts, but as I have spent a good deal of time over the problem I will point out some of the necessities of the case.

(1) With small samples the value certainly lies nearer to zero than the real value of R, *e.g.*

samples of 2 : mean at $\frac{2}{\pi}\sin^{-1} R$,

samples of 4 (real value ·66) ·561* ± ·011,

samples of 8 (real value ·66) ·614† ± ·065.

But with samples of 30 (real value ·66) mean at ·6609 ± ·0067 shows that the mean value approaches the real value comparatively rapidly.

(2) The standard deviation is larger than accords with the formula $\frac{1-r^2}{\sqrt{n-1}}$ even if we give the mean value of r for samples of the size taken, *e.g.* for samples of 2,

$$\text{S.D.} = \sqrt{1 - \left(\frac{2}{\pi}\sin^{-1} R\right)^2}.$$

For samples of 4, calculated‡ ·3957 ± ·0069; actual ·4680,

" " 8 " ·2355 ± ·0041; actual ·2684.

But samples of 30 calculated ·1046 ± ·0018, actual ·1001, again show that with samples as large as 30 the ordinary formula is justified.

(3) When there was no correlation the range found by fitting a Pearson curve to the distribution was accurately 2 in the theoretical case of samples of two, and well within the probable error for empirical distributions of samples of 4 and 8. But when we have correlation this process does not give the range closely for the empirical distribution (samples of 4 give 2·137, samples of 8 2·699, samples of 30 infinity) and the range calculated from samples of 2, which is

$$\frac{2\sqrt{4 + 3\mu_2 + 18\mu_2^2 - 9\mu_2^3}}{3 + \mu_2},$$

$\left(\text{where } \mu_2 = 1 - \left(\frac{2}{\pi}\sin^{-1} R\right)^2\right)$ is always less than 2 except in the case where μ_2 is 1, *i.e.* when there is no correlation.

Hence the distribution probably cannot be represented by any of Prof. Pearson's types of frequency curve unless $R = 0$.

(4) The distribution is skew with a tail towards zero.

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* The value must be slightly larger than this (perhaps even by ·03) as Sheppard's corrections were not used.

† Again higher, but not by more than ·02.

‡ $\frac{1-r^2}{\sqrt{n-1}}$ where r is taken as the mean value for the size of the sample. If we took the real value R, the difference would be even greater.

(5) To sum up:—If $y = \phi(x, R, n)$ be the equation, it must satisfy the following requirements. If $R = 1$, 1 is the only value of x which gives the value of y other than zero. If $n = 2$, ± 1 are the only values of x to do so. If $R = 0$ the equation probably reduces to $y = y_0 (1 - x^2)^{\frac{n-4}{2}}$.

Conclusions.

It has been shown that when there is no correlation between two normally distributed variables $y = y_0 (1 - x^2)^{\frac{n-4}{2}}$ gives fairly closely the distribution of r found from samples of n.

Next, the general problem has been stated and three distributions of r have been given which show the sort of variation which occurs. I hope they may serve as illustrations for the successful solver of the problem.

ZUR FRAGE VOM VIERGLIEDERIGEN TARSUS DER BLATTIDAE UND DER REGENERATION DER FÜSSE DERSELBEN.

Von TH. S. SCHTSCHERBAKOW (Laboratorium des Zoolog. Museums der Universität Moskau).

In den Jahren 1897/98 wurde eine interessante Untersuchung von *H. H. Brindley** veröffentlicht zur Frage der Regeneration der Füsse der *Blattidae* in Zusammenhang mit der Erscheinung eines viergliederigen Tarsus bei denselben. Diese Abhandlung beruhte auf einer grossen Menge Materials. Der Autor hat beinahe bewiesen, dass der viergliedrige Tarsus der Schaben ein Regenerationsprodukt ist, und keine "congenital variation" Erscheinung.

Ich nahm mir vor, seine Schlussfolgerungen statistisch zu kontrollieren, da ich 4839 Stück *Stylopyga orientalis* zur Verfügung hatte. Darunter waren erwachsen und geschlechtsreif (22—27 mm. lang) 1768 Exemplare, 402 ♂♂ und 1366 ♀♀; nicht geschlechtsreif waren 250 Stück (von 15—20 mm. Länge); deren Geschlecht nicht festgestellt wurde, da ich die hierzu erforderlichen Sektionen nicht vornahm; ebensolcher Individuen (von 10—15 mm. Länge) gab es 554, und ebenso geschlechtsunreifer, vor kurzem aus dem Kokon gekommener (von 10—5 mm. Länge und kleiner) hatte ich 2267 Stück. *Brindley* hatte nur 3611 Exemplare derselben Art zur Verfügung: 1635 "adult," d. h. geschlechtsreifer, und 1976 "young" (nicht geschlechtsreifer). Somit hatte ich mehr Material in meinen Händen, als *Brindley*, und zwar um 133 erwachsene und 1095 nicht geschlechtsreife Stück. Alle diese Individuen waren von mir im Laufe von etwa 2 Wochen (Ende April 1907 bis Anfang Mai desselben Jahres) in der Stadt Serpuchow (Gouvernement Moskau, Zentralrussland) gefangen worden, in der Küche eines Hauses, in dem die Schaben fast gar nicht verfolgt wurden und reichliche Nahrung fanden in Form von rohen und gekochten Kartoffeln und russischen Roggenbrotes, die in für die Nacht unverschlossenen Tischen und Schränken aufbewahrt wurden. Das Sammeln fand in folgender Weise statt: regelmässig jede Nacht bewaffnete ich mich mit einer entomologischen, flachendigen Pinzette und einem grossen Glasgefäss mit Spiritus und fing die Schaben auf der Diele, an den Wänden, in den Schränken, indem ich jedes Stück vorsichtig mit der Pinzette griff und sofort in den Spiritus warf. Auf diese Art fing ich sehr wenig Schaben, verscheuchte sie vielmehr. Darum wandte ich ferner folgende Methode an: ich umband die Aussenseite niedriger messingener, eiserner Schüsseln und Glasgefässe mit Lappen, um den Schaben den Zutritt zum Innern dieser Gefässe zu erleichtern und legte grosse Stücke Roggenbrot (frisches) in dieselben hinein, nachdem ich die obere Fläche dieser Stücke mit ungereinigtem Vaselin beschmiert hatte, der gehörig mit einer schwachen Lösung Arseniksalz vermengt war. Letzteres wurde dem Vaselin zu dem Zwecke beigemengt, damit die Schaben, nachdem sie vom Brot und Vaselin genossen hatten, nicht im Gefässe herumliefen und ihre Füsse nicht beschädigten, und wenn sie in den Schüsseln von einem Ende zum andern rannten unter den Dutzenden und Hunderten ihrer Gefährten, sich nicht gegenseitig drückten und zu Krüppeln machten. In der Tat fand ich am Morgen in den Gefässen Schaben, die nicht mehr zu schnellem Laufe fähig waren, wohl aber noch lebten und langsam umherkrochen. Der ganze Fang wurde am Morgen in Spiritus geworfen. Diese Fangweise ergab gute Resultate; nur ihr habe ich die grosse Menge behender, junger Schaben zu verdanken. In dem Hause, in dem ich den Fang ausübte, lebte *nur ausschliesslich* die eine Art *Stylopyga orientalis,* davon überzeugte ich mich durch eine Reihe von Besichtigungen und Nachsuchen. Daher bestand mein Material nur aus Repräsentanten dieser Art und unter der ganzen Menge geschlechtsunreifer Individuen, die mir als Material dienten, gab es nicht ein einziges Exemplar *Phyllodromia germanica.* So hatte ich ein absolut reines, reiches Material zur Verfügung. Nach Durchsicht des ganzen Materials an schwarzen Schaben erhielt ich folgende Zahlen:

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* *Proc. Zoolog. Soc.* London, 1897, pp. 903—916, 1898, p. 924 ff.

Geschlechtsreife Individuen.

Im ganzen 1768 Stück. 402 ♂♂, 1366 ♀♀. Fälle mit viergliedrigem Tarsus im ganzen 427. Allerlei Mutilationen 313*.

Nichtgeschlechtsreife Individuen.

(*a*) Länge 15—20 mm.

250 Stück. Fälle mit 4-gliedrigem Tarsus im ganzen 47. Allerlei Mutilationen 18.

(*b*) Länge 10—15 mm.

554 Stück. Fälle mit 4-gliedrigem Tarsus im ganzen 51. Allerlei Mutilationen 19.

(*c*) Länge 10—5 mm. und *kleiner.*

2267 Stück. Fälle mit 4-gliedrigem Tarsus im ganzen 5. Allerlei Mutilationen 0†.

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* Unter "Mutilation" verstehe ich allerlei Brüche der Tarsen (Füsse) an verschiedenen Gelenken, Beschädigungen und allerlei Verkrüppelungen an denselben und ihren Teilen.

† Es gab wohl Mutilationen unter den Individuen von dieser Grösse, aber in Rücksicht darauf, dass das Material höchst spröde und brüchig und in starkem Spiritus gelegen hatte, habe ich dieselben nicht mit in Rechnung gezogen, da ich annehme, dass sie durch das Herausholen des Materials aus dem Gefäss entstanden sind.

Im ganzen 4839 Stück. Gesamtzahl der Fälle mit 4-gliedrigem Tarsus 530. Gesamtzahl der Mutilationen 350.

In Prozenten ausgedrückt würden unsere Zahlen wie folgt erscheinen:

Geschlechtsreife Individuen; °/o der 4-gliedrigen Tarsus im Verhältnis zur

Gesamtzahl der Individuen:	zur Zahl der ♂♂:	zur Zahl der ♀♀:
24,15	20,69	25,109.

Geschlechtsunreife Individuen; °/o der 4-gliedrigen Tarsus für

(*a*)	Individuen von	15—20	mm.	Länge	——	18,8
(*b*)	„ „	10—15	„	„	——	9,205
(*c*)	„ „	10—5	„	„	und kleiner	0,22.

Für die Gesamtzahl der geschlechtsunreifen Individuen 3,35.

Für die Gesamtzahl der geschlechtsreifen und geschlechtsunreifen Individuen 10,95.

Wenn wir unsere °/o-Zahlen mit denen von *H. Brindley* vergleichen, sehen wir, dass die °/o-Zahlen der viergliedrigen Tarsus für geschlechtsreife ♂♂ bei uns wie bei *Brindley* fast gleich sind (bei uns 20,69 °/o, bei *Brindley* 20,6 °/o). Der Prozentsatz der 4-gliedrigen Tarsus bei unseren ♀♀ ist höher als bei *Brindley* (bei uns 25,109 °/o, bei *Brindley* 21,8 °/o). Was aber die geschlechtsunreifen Individuen anbelangt, so hat *Brindley* nicht den Unterschied nach den Grösseverhältnissen durchgeführt. Wenn wir also die vorletzte Kategorie vergleichen, sehen wir, dass der °/o-Satz der 4-gliedrigen Tarsus bei allen geschlechtsunreifen Individuen bei uns viel niedriger ist, als bei *Brindley* (bei uns 3,35 °/o, bei *Brindley* 16,4 °/o). Der Gesamtprozentsatz der 4-gliedrigen Tarsus für alle geschlechtsreifen und geschlechtsunreifen Individuen ist bei uns ebenfalls bedeutend niedriger (bei uns 10,95 °/o, bei *Brindley* 18,7 °/o). Ein so niedriger Prozentsatz an 4-gliedrigen Tarsus für die Gesamtzahl der Individuen überhaupt und ebenso für die geschlechtsunreifen Formen bei mir, lässt sich dadurch erklären, wie ich annehme, dass ich ein 1½ mal grössere Anzahl von geschlechtsunreifen Individuen bearbeitete, als von geschlechtsreifen. Ich hatte an geschlechtsunreifen Individuen um 1095 Stück mehr zur Verfügung, als *Brindley* (d. h. 3071, *Brindley* aber 1976). Man muss berücksichtigen, wie schnell der °/o-Satz der 4-gliedrigen Tarsus mit dem Sinken der Grössenverhältnisse fällt. Besonders in die Augen fallend ist der Sprung des °/o-Satzes beim Übergang von den 10–15 mm. langen Individuen zu den 10–5 mm. langen und noch kleineren Stücken. Hätte *H. Brindley* die doppelte Zahl junger Schaben zur Verfügung gehabt, so hätte auch er andere °/o Verhältnisse erhalten.

Gehen wir an eine weitere Analyse unserer Daten, um sie mit den Ergebnissen *H. Brindleys* zu vergleichen.

"In the great majority of cases only one of the six legs bore a 4-jointed tarsus, though many individuals possessed the abnormality on more than one leg," schreibt

H. Brindley. Er fand, dass in der Gradation bei der schwarzen Schabe sich folgendes beobachten lässt:

4-gliedrige Tarsus:

an 1 Fuss,	an 2 Füssen,	an 3 Füssen,	an 4 Füssen,	an 5 Füssen,	an 6 Füssen.
588 Fälle,	108 Fälle,	23 Fälle,	10 Fälle,	0 Fälle,	4 Fälle.

Ich habe meinerseits nach meinen Berechnungen folgende Resultate erhalten:

4-gliedrige Tarsus:

bei der Gesamtzahl aller Individuen ("adult" und "young"):

an 1 Fuss,	an 2 Füssen,	an 3 Füssen,	an 4 Füssen,	an 5 Füssen,	an 6 Füssen.
397 Fälle,	67 Fälle,	5 Fälle,	1 Fall,	0 Fälle,	0 Fälle.

Wenn man aber dieselben Daten nach der Körperlänge geordnet durchmustert, so kommt man zu folgendem Resultate:

Geschlechtsreife Individuen:

an 1Fuss,	an 2 Füssen,	an 3 Füssen,	an 4 Füssen,	an 5 Füssen,	an 6 Füssen.
313 Fälle,	58 Fälle,	5 Fälle,	1 Fall,	0 Fälle,	0 Fälle.

Geschlechtsunreife Individuen:

(*a*) Länge 15—20 mm.

an 1 Fuss,	an 2 Füssen,	an 3 Füssen,	an 4 Füssen,	an 5 Füssen,	an 6 Füssen.
37 Fälle,	5 Fälle,	0 Fälle,	0 —,	0 —,	0 —.

(*b*) Länge 10—15 mm.

an 1 Fuss,	an 2 Füssen,	an 3 Füssen,	an 4 Füssen,	an 5 Füssen,	an 6 Füssen.
44 Fälle,	3 Fälle,	0 —,	0 —,	0 —,	0 —.

(*c*) Länge 10—5 mm. und kleiner.

an 1 Fuss,	an 2 Füssen,	an 3 Füssen,	an 4 Füssen,	an 5 Füssen,	an 6 Füssen.
3 Fälle,	1 Fall,	0 —,	0 —,	0 —,	0 —.

Brindley's Zahlen sind viel höher, als unsere (wenn man die Daten seiner Tabelle mit denen der meinigen hinsichtlich der Gesamtzahl aller Individuen vergleicht). Bemerkt muss noch werden, dass mir *eine* der von mir untersuchten Schaben einen 4-gliedrigen Tarsus an vier Füssen zugleich hatte. Mehr als 4 anomale Tarsus bei ein und demselben Individuum habe ich kein Mal gefunden, während der englische Verfasser 4 anomale Tarsus in 10 Fällen hatte und 6 anomale in vier Fällen.

Man muss bedauern, dass *Brindley* die Anzahl anomaler Tarsus, die gleichzeitig bei *einem* Individuum vorkommen, nicht nach Altersgruppen geordnet untersucht hat, indem er letztere durch die Längenmasse des Körpers bezeichnete. Meine Daten weisen sehr lehrreiche und interessante Sprünge in der Zahl der Fälle von anomalen Tarsus bei einem Individuum beim Übergange zur letzten Altersgruppe auf. Nur bei einem von 2267 Individuen von 10—5 mm. Länge und kleiner wurden anomale Tarsus an zwei Füssen zugleich beobachtet und nur bei 3 Stück, die zu derselben Grössenkategorie gehörten, wurde ein anomaler Tarsus an einem Fusse beobachtet! Alle übrigen Individuen hatten also vollkommen normale Füsse. Wir wollen auch noch hervorheben, dass nicht ein einziges geschlechtsunreifes Individuum mehr als an zwei Füssen anomale Tarsus besass.

Brindley fand, dass bei den von ihm untersuchten schwarzen Schaben folgende Häufigkeit der anomalen Tarsus in der Reihenfolge jedes der drei Beinpaare (in Prozenten ausgedrückt) statt hatte:

	1tes Beinpaar:	2tes Beinpaar:	3tes Beinpaar:
"adult":	26,9 °/o	22,9 °/o	50,2 °/o
"young":	15,7 °/o	27,7 °/o	56,4 °/o
"total":	21,4 °/o	25,4 °/o	53,2 °/o

Nach meiner Berechnung erhielt ich folgende Resultate:

Geschlechtsreife Individuen:		
28,33 °/o	24,12 °/o	47,54 °/o
Nichtgeschlechtsreife Individuen:		
20,38 °/o	27,18 °/o	49,51 °/o
"Total":		
26,79 °/o	24,71 °/o	48,47 °/o
Nichtgeschlechtsreife Individuen (nach Altersgruppen):		
(*a*) Länge 15—20 mm.:		
5,17 °/o	7,05 °/o	9,87 °/o
(*b*) Länge 15—10 mm.:		
4,08 °/o	6,63 °/o	15,3 °/o
(*c*) Länge 10—5 mm. und kleiner:		
0,1 °/o	0 °/o	0,15 °/o

Bei den von mir untersuchten geschlechtsreifen Formen war der °/o-Satz der anomalen Tarsus am 1sten Paar Füsse um 1,43 °/o höher, als bei *Brindley*. Am 2ten Beinpaar bei denselben Individuen ist mein Prozentsatz um 1,22 °/o höher, am dritten Beinpaar um 2,66 °/o *niedriger*, als bei *Brindley*. Was die jungen Stücke anbelangt, so ist mein Prozentsatz für das 1te Beinpaar um 4,68 °/o höher, für das 2te um 0,52 °/o niedriger, für das 3te ebenfalls um 6,89 °/o niedriger. Was aber die Rubrik "Total" anbetrifft, so steht die Sache folgendermassen: für das erste Beinpaar sind meine Zahlen um 5,39 °/o höher, als die von *Brindley*, für das 2te um 0,69 °/o niedriger und für das 3te auch um 4,73 °/o geringer. Die Daten für die Nichtgeschlechtsreifen nach Altersgruppen lassen sich nicht vergleichen, da in *Brindley's* Tabellen diese Kategorie fehlt.

Sehr interessant ist der Umstand, dass sowohl in meiner wie in *Brindley's* Tabelle der °/o-Satz der 4-gliedrigen Tarsus für das 2te Beinpaar bei den "adult" *niedriger* ist als für das 1^{ste} Beinpaar. Bei den als "young" bezeichneten Individuen (nichtgeschlechtsreif) ist derselbe $^\circ/_0$-Satz höher. In der Kategorie "Total" ist derselbe bei *Brindley* höher, bei mir geringer. Wenn man aber die nichtgeschlechtsreifen Individuen nach Altersstufen untersucht, so wächst derselbe, während er in der Gruppe 10—5 mm. und kleiner = 0 ist, in der folgenden Gruppe plötzlich, indem er viel höher sich stellt, als der entsprechende $^\circ/_0$-Satz für das 1^{ste} Beinpaar. Warum fällt er in der Kategorie "adult"?

"The long third pair of legs seem to suffer more from their exposed condition, as compared with the less extended anterior pairs," sagt *Brindley.* Warum aber hat das zweite Paar Beine einen geringeren Prozentsatz anomaler Tarsus? Mir scheint deshalb, weil es zwischen dem ersten und dritten Paar befindlich mehr vor Zufällen von hinten geschützt ist, als das dritte Paar, und von vorne mehr als das erste. Vor allem leiden durch allerlei Verletzungen die beiden äussersten Paare—das erste und dritte, und dann erst das zweite, das sich zwischen ihnen befindet, wie zwischen zwei Schilden. Diese Erklärung passt aber nur für die Kategorie "adult," die geschlechtsreifen Individuen, und lässt sich durchaus nicht auf die "young" und nichtgeschlechtsreifen Tiere anwenden. Bei letzteren wächst der Prozentsatz anomaler Tarsus mit dem Übergange vom ersten Paar zum zweiten und von diesem zum dritten.

Gehen wir jetzt zur weiteren Analyse unserer Daten im Vergleich zu denen in *Brindley's* Arbeit über.

"The abnormal tarsi occurred indifferently on the right and left sides—thus, in 1329 cases in *S. orientalis* 661 were on the right and 668 on the left side," schreibt *Brindley.* Meine Zahlen ergeben dasselbe:

Geschlechtsreife Individuen:

ein viergliederiger Tarsus fand sich

auf der linken Seite:	auf der rechten Seite:
in 212 Fällen	in 215 Fällen
Geschlechtsunreife Individuen:	
(*a*) Länge 15—20 mm.:	
in 24 „	in 23 „
(*b*) Länge 10—15 mm.:	
„ 24 „	„ 27 „
(*c*) Länge 10—5 mm. und kleiner:	
„ 3 „	„ 2 „
Gesamtzahl für die Geschlechtsunreifen:	
„ 51 „	„ 52 „
Gesamtzahl für beide Kategorien:	
„ 263 „	„ 267 „

Eine solche Unterschiedslosigkeit für das Verhalten der rechten und linken Seite ist ohne jede Erklärung klar begreiflich.

H. Brindley stellte auf experimentellem Wege fest, dass nach entsprechenden Verletzungen der Tarsen, die schwarzen Schaben nach den Häutungen viergliedrige Tarsus erhielten. Er sagt in seiner Arbeit nichts darüber, ob er irgend welche Verwundungen oder Trauma an dem von ihm untersuchten und konservierten Material vorfand, und wenn er solche vorgefunden hat, weshalb hat er diese Erscheinungen nicht untersucht, weshalb hat er dieselben, so zu sagen, als quantité négligeable angesehen?

Als ich mein konserviertes Material durchmusterte, fand ich am selben nicht wenig verschiedenartige Traumata. In meinen Notizen vermerkte ich bloss die *Traumata ante captivationem.* Die letzteren besitzen charakteristische Merkmale, die es gestatten, sie unter den Fällen von Traumata post mortem zu erkennen: das ist eine schwarzbraune Narbe an der Stelle der Verwundung, eine gewisse Runzelung des Chitins um dieselbe; ähnliche Merkmale beobachtete ich auch an lebenden Tarakanen (Schaben), die ich in Käfigen hielt, nachdem ich ihnen vorher die Füsse an verschiedenen Gelenkstellen beschnitten hatte. *H. Brindley* selbst sagt, dass bei einer Schabe, die in spirito gelegen habe, eine leichte Brüchigkeit der Beine in der Gegend des tarso-tibialen Gelenkes zu bemerken ist, während Femur und Tibia nur gewaltsam getrennt werden können. Die Verwundungen ante captivationem sind scharf unterschiedbar von den Traumata post captivationem et post mortem: eine Narbe mit scharfem Dunkelwerden des Chitins in letzterem Falle habe ich nie beobachtet, während dieses für Verwundungen der ersten Kategorie charakteristisch ist. Es ist natürlich möglich, dass in meinen Zahlen sich Ungenauigkeiten finden: bei dem eiligen Fange von Schaben mit der Pinzette in der Hand konnte ich ihnen Verletzungen zufügen—und oft entkamen mir solche Schaben und gerieten dann vielleicht nach einigen Tagen unter mein Material, indem sie in die Fanggefässe krochen. Andererseits konnte ich mit der Pinzette in den Spiritus Schaben werfen, und ihnen hierbei die Füsse verletzen und diese konnten keine Narbe an der Verwundungsstelle bilden und gerieten auf diese Weise in die Kategorie der Verwundungen post captivationem et mortem, welche ich nicht registrierte. Wenn man aber in Betracht zieht, dass diese beiden Reihen von Verletzungen beim Fange einander entgegengesetzt sind in Hinsicht der Registration der Traumata, und wenn man im Auge behält, dass ich mit der entomologischen Pinzette, wie oben gesagt, verhältnismässig wenig Schaben gefangen habe, so glaube ich, dass in meinen Zahlen nur eine geringe Ungenauigkeit vorwalten kann.

Und somit wollen wir an die Betrachtung der Traumata gehen. Vor allem will ich mitteilen, welcher Art Verletzungen ich beobachtete und registrierte. Zerreissungen im Gebiet der tarso-tibialen und Femoro-trochanter-Gelenke (sehr selten im Gebiet der tibio-femoralen Einlenkungen), Brüche der einzelnen Tarsenglieder, Abbrechen der Krallen sowohl am normalen fünfgliedrigen, wie auch am anomalen viergliedrigen Tarsus—das sind die bei meinem Material häufigsten

Traumafälle. Alle diese Traumata wurden an geschlechtsreifen Individuen gefunden; bei den nichtgeschlechtsreifen wurden dieselben Verletzungen bemerkt, ausgenommen die tibio-femoralen Zerreissungen, die niemals bei ihnen beobachtet wurden. Ausserdem wurden einige andere Verletzungen registriert: Zerreissungen in der Trochantero-coxal-Einlenkung (ein Fall bei einem Imago ♂), Abbrechen des *ganzen* Fusses (1 Fall bei einem Imago ♂), Abbruch des ganzen Tarsus und Verkrümmung des Tibiaendes (1 Fall bei einem ♂-Imago), Abbruch, der fast mitten über das erste (von der Tibia aus gerechnet) Tarsusglied ging, so dass die Hälfte des Gliedes erhalten blieb (1 Fall bei einem Individuum bei der Kategorie 15—20 mm. langer Larven), Abbruch des ganzen Tarsus und Verkrüppelung der Tibia (1 Fall bei einem Individuum aus der Kategorie 10—15 mm. langer Larven).

Gehen wir an die Durchsicht der ziffernmässigen Daten hinsichtlich der Verwundungen und beginnen wir mit den geschlechtsreifen Individuen. In dieser Kategorie waren alle abmassgeführten Verletzungen bei 231 Individuen beobachtet worden, ♂♂ 90 und ♀♀ 141, oder in Prozenten ausgedrückt bei 13,06 °/₀ beider Geschlechter, bei 22,43 °/₀ aller Männchen u. bei 10,32 °/₀ aller Weibchen. Die hierher gehörigen Zahlen sind folgende:

Traumata bei Geschlechtsreifen:

Tarso-tibiale Traumata:

im ganzen 124 Fälle von Trauma:

am	1sten	rechten	Fuss	8	Fälle	17 Fälle—in °/₀ °/₀ = 13,7 °/₀.
„	„	linken	„	9	„	
„	2ten	rechten	„	20	„	37 Fälle—„ „ = 29,83 °/₀.
„	„	linken	„	17	„	
„	3ten	rechten	„	35	„	70 „ —„ „ = 56,45 °/₀.
„	„	linken	„	35	„	

Femoro-trochanter-Traumata:

im ganzen 109 Fälle von Trauma:

am	1sten	rechten	Fuss	10	Fälle	23 Fälle, in °/₀ °/₀ = 21,1 °/₀.
„	„	linken	„	13	„	
„	2ten	rechten	„	11	„	25 „ „ „ = 23,02 °/₀.
„	„	linken	„	14	„	
„	3ten	rechten	„	27	„	61 „ „ „ = 55,96 °/₀.
„	„	linken	„	34	„	

Abbruch der Krallen (fünfgliedriger Tarsus), im ganzen 22 Fälle:

am	1sten	rechten	Fuss	3	Fälle	5 Fälle, in °/₀ °/₀ = 22,72 °/₀.
„	„	linken	„	2	„	
„	2ten	rechten	„	5	„	9 „ „ „ = 40,90 °/₀.
„	„	linken	„	4	„	
„	3ten	rechten	„	6	„	8 „ „ „ = 36,36 °/₀.
	„	linken	„	2	„	

Abbruch der Krallen (viergliedriger Tarsus):

im ganzen 3 Fälle:

am 1sten	rechten	Fuss	1 Fall	das prozentuale Verhältnis wurde nicht berechnet.
„ „	linken	„	0 Fälle	
„ 2ten	rechten	„	0 „	
„ „	linken	„	0 „	
„ 3ten	rechten	„	2 „	
„ „	linken	„	0 „	

Abbruch der Tarsusglieder:

im ganzen 43 Fälle:

4 Glieder abgebrochen : 6 Fälle, in % % = 13,95 %
3 „ „ : 4 „ „ „ = 9,3 %
2 „ „ : 9 „ „ „ = 20,93 %
1 Glied „ : 24 „ „ „ = 55,8 %.

am 1sten	rechten	Fuss	8 Fälle von Abbruch	12, in % % = 27,9 %
„ „	linken	„	4 „ „ „	
„ 2ten	rechten	„	4 „ „ „	9, „ „ = 20,93 %
„ „	linken	„	5 „ „ „	
„ 3ten	rechten	„	11 „ „ „	22, „ „ = 51,16 %
„ „	linken	„	11 „ „ „	

Tibio-femorale Traumata:

im ganzen 4 Fälle:

am 1sten	rechten	Fuss	0 Fälle	0	das prozentuale Verhältnis wurde nicht berechnet.
„ „	linken	„	0 „		
„ 2ten	rechten	„	0 „	3	
„ „	linken	„	3 „		
„ 3ten	rechten	„	1 Fall	1	
„ „	linken	„	0 „		

Trochantero-coxale Traumata:

im ganzen 1 Fall:

am 3ten rechten Fuss:

Abbruch des ganzen Fusses:

im ganzen 1 Fall:

am 1sten rechten Fuss.

Abbruch des Tarsus und Vorbiegung der Tibia:

im ganzen 1 Fall:

am 3ten linken Fuss.

Wenden wir uns den Traumata bei geschlechtsunreifen Individuen zu und sehen wir uns zuerst die Traumata überhaupt für alle geschlechtsunreifen Formen an.

Traumata bei der Gesamtheit der Geschlechtsunreifen:

Tarso-tibiale Traumata:

im ganzen 13 Fälle:

am	1sten	rechten	Fuss	1	Fall	1, in °/₀ °/₀ = 7,68 °/₀
„	„	linken	„	0	Fälle	
„	2ten	rechten	„	1	Fall	4, „ „ = 30,72 °/₀
„	„	linken	„	3	Fälle	
„	3ten	rechten	„	5	„	8, „ „ = 61,44 °/₀.
„	„	linken	„	3	„	

Femoro-trochanter-Traumata:

im ganzen 11 Fälle:

am	1sten	rechten	Fuss	0	Fälle	1, in °/₀ °/₀ = 9,09 °/₀
„	„	linken	„	1	Fall	
„	2ten	rechten	„	1	„	3, „ „ = 27,27 °/₀
„	„	linken	„	2	Fälle	
„	3ten	rechten	„	3	„	7, „ „ = 63,63 °/₀.
„	„	linken	„	4	„	

Abbruch von Krallen (fünfgliedriger Tarsus):

im ganzen 6 Fälle:

am	1sten	rechten	Fuss	1	Fall	2, in °/₀ °/₀ = 33,2 °/₀
„	„	linken	„	1	„	
„	2ten	rechten	„	2	Fälle	3, „ „ = 49,8 °/₀
„	„	linken	„	1	Fall	
„	3ten	rechten	„	1	„	1, „ „ = 16,6 °/₀.
„	„	linken	„	0	Fälle	

Abbruch von Tarsusgliedern:

im ganzen 5 Fälle:

Abgebrochen 4 Glieder, 0 Fälle, in °/₀ °/₀ = 0 °/₀
„ 3 „ , 0 „ , „ „ = 0 °/₀
„ 2 „ , 1 Fall, „ „ = 20 °/₀
„ 1 Glied , 4 Fälle, „ „ = 80 °/₀.

am	1sten	rechten	Fuss	1	Fall	2, in °/₀ °/₀ = 40 °/₀
„	„	linken	„	1	„	
„	2ten	rechten	„	0	Fälle	1, „ „ = 20 °/₀
„	„	linken	„	1	Fall	
„	3ten	rechten	„	2	Fälle	2, „ „ = 40 °/₀.
„	„	linken	„	0	„	

Wenden wir uns nun den Traumata bei denselben geschlechtsunreifen Individuen zu, indem wir sie nach den schon oben angegebenen Altersabstufungen ordnen:

Geschlechtsunreife Individuen:

(*a*) Länge 15—20 mm.

Tarso-tibial-Traumata:

im ganzen 6 Fälle:

am 1sten	rechten Fuss	1 Fall	1, in °/₀ °/₀ = 16,6 °/₀
„ „	linken „	0 Fälle	
„ 2ten	rechten „	0 „	1, „ „ = 16,6 °/₀
„ „	linken „	1 Fall	
„ 3ten	rechten „	3 Fälle	4, „ „ = 66,6 °/₀.
„ „	linken „	1 Fall	

Femoro-trochanter-Traumata:

im ganzen 5 Fälle:

am 1sten	rechten Fuss	0 Fälle	1, in °/₀ °/₀ = 20 °/₀
„ „	linken „	1 Fall	
„ 2ten	rechten „	1 „	1, „ „ = 20 °/₀
„ „	linken „	0 Fälle	
„ 3ten	rechten „	2 „	3, „ „ = 60 °/₀.
„ „	linken „	1 Fall	

Abbruch der Krallen (fünfgliedriger Tarsus):

im ganzen 3 Fälle:

am 1sten	rechten Fuss	1 Fall	1	in °/₀ °/₀ = 33,3 °/₀.
„ „	linken „	0 Fälle		
„ 2ten	rechten „	1 Fall	1	
„ „	linken „	0 Fälle		
„ 3ten	rechten „	1 Fall	1	
„ „	linken „	0 Fälle		

Abbruch von Tarsengliedern:

im ganzen 3 Fälle:

4 Glieder abgebrochen : 0 Fälle, in °/₀ °/₀ = 0 °/₀
3 „ „ : 0 „ „ „ = 0 °/₀
2 „ „ : 1 Fall „ „ = 33,3 °/₀
1 Glied „ : 2 Fälle „ „ = 66,6 °/₀.

am 1sten	rechten Fuss	1 Fall	1, in °/₀ °/₀ = 33,3 °/₀
„ „	linken „	0 Fälle	
„ 2ten	rechten „	0 „	0, „ „ = 0 °/₀
„ „	linken „	0 „	
„ 3ten	rechten „	2 „	2, „ „ = 66,6 °/₀.
„ „	linken „	0 „	

Abbruch des ersten Tarsengliedes in der Mitte seiner Länge:
ein Fall:
am 3ten linken Fuss.

(*b*) Länge 10—15 mm.

Tarso-tibial-Traumata:
im ganzen 7 Fälle:

am	1sten	rechten Fuss	0 Fälle	0, in °/₀ °/₀ = 0 °/₀
„	„	linken „	0 „	
„	2ten	rechten „	1 Fall	3, „ „ = 42,84 °/₀
„	„	linken „	2 Fälle	
„	3ten	rechten „	2 „	4, „ „ = 57,12 °/₀.
„	„	linken „	2 „	

Femoro-trochanter-Traumata:
im ganzen 6 Fälle:

am	1sten	rechten Fuss	0 Fälle	0, in °/₀ °/₀ = 0 °/₀
„	„	linken „	0 „	
„	2ten	rechten „	0 „	2, „ „ = 33,2 °/₀
„	„	linken „	2 „	
„	3ten	rechten „	1 Fall	4, „ „ = 66,4 °/₀.
„	„	linken „	3 Fälle	

Abbruch der Krallen (5-gliedriger Tarsus):
im ganzen 3 Fälle:

am	1sten	rechten Fuss	0 Fälle	1, in °/₀ °/₀ = 33,3 °/₀
„	„	linken „	1 Fall	
„	2ten	rechten „	1 „	2, „ „ = 66,6 °/₀
„	„	linken „	1 „	
„	3ten	rechten „	0 Fälle	0, „ „ = 0 °/₀.
„	„	linken „	0 „	

Abbruch von Tarsengliedern:
im ganzen 2 Fälle:

4	Glieder	abgebrochen	: 0	Fälle, in °/₀ °/₀ = 0 °/₀
3	„	„	: 0	„ , „ „ = 0 °/₀
2	„	„	: 0	„ , „ „ = 0 °/₀
1	Glied	„	: 2	„ , „ „ = 100 °/₀.

am	1sten	rechten Fuss	0 Fälle	1, in °/₀ °/₀ = 50 °/₀
„	„	linken „	1 Fall	
„	2ten	rechten „	0 Fälle	1, „ „ = 50 °/₀
„	„	linken „	1 Fall	
„	3ten	rechten „	0 Fälle	0, „ „ = 0 °/₀.
„	„	linken „	0 „	

Abbruch des ganzen Tarsus und verkrüppelte Tibia:
im ganzen 1 Fall:
am 2^{ten} rechten Fuss.
(*c*) Länge 10—5 mm. und kleiner:
kein Fall.

(Verkrüppelungen und Traumata wurden nicht registriert, weil sie in Menge als Erscheinungen post captivationem et mortem auftraten.)

Wir sahen schon oben, dass der Prozentsatz der anomalen (viergliedrigen) Tarsus mit dem Übergange von jedem nach vorne gelegenen Beinpaare zum folgenden steigt und dass besonders dieses Ansteigen am dritten Fusspaar bedeutend erscheint. Wenn wir nun die Traumata nehmen, so sehen wir, dass dieselbe Gesetzmässigkeit auch bei folgenden Traumata vorherrscht:

(1) bei den tarso-tibialen Traumata (bei geschlechtsreifen Individuen, bei den nichtgeschlechtsreifen überhaupt, in der Kategorie derselben von 15—20 mm. und von 10—15 mm Länge);

(2) bei den Femoro-trochanter-Traumata (bei geschlechtsreifen Individuen, bei den nichtgeschlechtsreifen überhaupt, bei denen der Kategorien 15—20 mm., sowie 10—15 mm. Länge).

(3) Abbruch von Tarsengliedern (bei geschlechtsreifen Individuen, nichtgeschlechtsreifen überhaupt und denen der Kategorien 15—20 mm. und 10—15 mm. Länge). Was aber den Abbruch von Krallen anbelangt, so ist diese Art Trauma, während sie in Hinsicht auf Gesetzmässigkeit der oben angeführten analog ist bei den Individuen die die Geschlechtsreife erlangten, bei den nichtgeschlechtsreifen Tieren keiner greifbaren Gesetzmässigkeit unterworfen (oder eher ohne alle Gesetzmässigkeit). Alle übrigen Fälle von Traumata (tibio-femorale u. s. w.) unterliegen gar keiner Gesetzmässigkeit.

Wenden wir nun unsere Aufmerksamkeit den tarso-tibialen und femoro-trochanter-Traumata zu. *H. Brindley* weist bei Mitteilung über seine Versuche über die Regeneration des Tarsus bei der schwarzen Schabe in die Tabelle E seiner Arbeit darauf hin, was für Verletzungen und an welchen Stellen der Beine er sie den von ihm zu Experimenten benutzten Schaben beibrachte.

Unten gebe ich diese Tabelle wieder und füge derselben rechts ein Rubrik bei, in welcher ich die Prozentsätze der regenerierten 4-gliedrigen Tarsus ausrechnete.

Aus dieser Tabelle ersehen wir, dass ausser der oberen Rubrik ("t_2 torn away from t_1"), die tarso-tibialen und Femoro-trochanter-Traumata den grössten Prozentsatz regenerierter viergliedriger Tarsen lieferten. Hierbei wollen wir hervorheben, dass die Entfernung der bezeichneten Glieder nicht mit Instrumenten (z. B. "scissors"), sondern so geschah, wie es unter natürlichen Verhältnissen des Schabenlebens vor sich geht—durch einfaches Abreissen eines Gliedes von dem andern. Aber das ist noch nicht genügend, die Form der Verletzung selbst, das Abreissen eines Gliedes vom andern *an der Stelle der Einlenkung*, entspricht

*H. Brindley's Tabelle E**.

Nature of Mutilation	Leg Mutilated	Number of Mutilations	Number of Reproductions Observed	°/₀ °/₀
t_2 torn away from t_1 ...	3*R*	300	141	47 °/₀
t_1 divided with scissors ...	2*L* 3*L*	21 109	3 16	14,61 °/₀
	Totals	130	19	
Tarsus torn away from tibia ...	2*R* 3*R*	300 89	144 45	48,58 °/₀
	Totals	389	189	
Tibia divided with scissors ...	3*R* 3*L*	14 300	2 122	39,42 °/₀
	Totals	314	124	
Femur torn away from trochanter	1*L* 2*R* 3*L*	300 17 23	137 4 11	44,7 °/₀
	Totals	340	152	
	Totals	1473	625	—

der Form von Traumata, die a priori einzig und allein im gewöhnlichen Leben des Insekts vorkommen kann, und die wir schon in unseren oben angeführten Tabellen von Traumata beobachteten. Traumata, die sich *nicht an den Einlenkungsstellen* finden, erscheinen für das gewöhnliche Leben der Schabe als Ausnahme und dabei, wie wir in den Tabellen sahen, als sehr seltene.

Hieraus folgt ganz direkt, dass die von uns in unseren Tabellen aufgeführten Traumata von gesetzmässigem Charakter (der gleich ist mit dem konsequenten Anwachsen des °/₀ am viergliedrigen Tarsus an jedem folgenden und besonders dem dritten Beinpaar) keine zufälligen sind, sondern notwendigerweise der Regeneration des viergliedrigen Tarsus vorausgehen, wobei das Maximum an Traumata gerade das Paar Beine trifft (das 3^{te}), das auch das Maximum anomaler Tarsus aufzuweisen hat. Der zweite Folgeschluss ist der, dass das Maximum an Verletzungen auf die tarso-tibialen und Femoro-trochanter-Einlenkungen, sowie den Abbruch von Tarsengliedern fällt. Die oben von uns an unserem Material untersuchten drei gesetzmässigen Arten von Traumata gehören gerade in die Reihe derjenigen die in *Brindley's* Versuchen das Maximum an regenerierten anomalen Tarsus ergaben. Es erscheint also der Schluss sehr wahrscheinlich und der Wirklichkeit sehr nahekommend, dass der viergliedrige Tarsus, den wir bei der schwarzen Schabe beobachten können, als ein Produkt der Regeneration nach Verletzungen der tibio-tarsalen oder Femoro-trochanter-Einlenkungen erscheint, oder des Abbrechens von Tarsusgliedern.

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* In dieser Tabelle sind folgende Bezeichnungen (nach *Brindley*): R und L = "right" und "left" = rechts u. links; 1, 2 und 3 bezeichnet die Beinpaare der Folge nach; t_1 und t_2 u. s. w. die Tarsenglieder, vom proximalen Gliede aus gerechnet.

Es ist wahrscheinlich, dass eine jede Verwundung des Schabenfusses (die nicht weiter reicht, als bis zur Femoro-trochanter-Einlenkung) als Choc erscheint, der eine anomale Regeneration der Tarsus hervorruft, aber nicht jede Art von Verwundung kommt im natürlichen Leben der Schabe vor. Die Neigung einiger weniger Einlenkungsstellen zu Traumabildungen im gewöhnlichen Leben der schwarzen Schabe steht, so zu sagen, wahrscheinlich in Abhängigkeit sowohl vom anatomischen Bau dieser Gelenke, im Vergleich zu anderen, als auch von der Art des Gehens und Laufens bei den Schaben. *Brindley* bemerkte schon, dass bei der schwarzen Schabe, wenn sie in Spiritus gelegen hatte, sich eine leichte Brüchigkeit der Tarso-tibial-Gelenke zeigt, während der Femur von der Tibia sich nur bei einiger Gewaltanwendung trennen lässt. Es wäre sehr interessant den Wiederstand zu untersuchen, den die verschiedenen Gelenke der Füsse der schwarzen Schabe dem Abgerissenwerden entgegensetzen.

Wenden wir uns wieder unseren Traumatabellen zu. Wenn wir zusehen, wie der Prozentsatz der obenbeschriebenen drei gesetzmässigen Trauma-Arten wächst mit dem Alter der Individuen, so bemerken wir, dass der Prozentsatz dieser Verletzungen bei den nichtgeschlechtsreifen Individuen nicht kleiner ist, als bei den geschlechtsreifen, d. h. dass die Zahl der Traumata mit dem Alter nicht zunimmt (wie man aus dem wenig zahlreichen Material an nichtgeschlechtsreifen Tieren schliessen könnte). Die Traumata stehen also nach den Altersgruppen in anderem Verhältnis zum Prinzip des Anwachsens des Prozentsatzes der Anomalien in Abhängigkeit vom Alter, als der anomale viergliedrige Tarsus. Hierin besteht der Grundunterschied der Traumata vom anomalen Tarsus. Wenn wir uns aber wenden dem Unterschiede der Traumata in Abhängigkeit vom Geschlechte zu, so sehen wir, dass der Prozentsatz an solchen bei den ♂♂ höher ist, als bei den ♀♀, während in Hinsicht des anomalen Tarsus die Sache umgekehrt liegt. Zeigt nicht das eine oder andere Geschlecht, so zu sagen, eine Neigung zu der einen oder andern Traumaform? Für diesen Fall habe ich folgende Zahlung zur Verfügung:

Tarso-tibial-Traumata:

wurden beobachtet bei 58 ♀♀ und 48 ♂♂.

Femoro-trochanter-Traumata:

wurden gefunden bei 62 ♀♀ und 37 ♂♂.

Abbruch der Tarsusglieder:

fand sich bei 21 ♀♀ und 17 ♂♂.

Abbruch der Klauen (am fünfgliedrigen Tarsus):

fand sich bei 14 ♀♀ und 7 ♂♂.

Die Zahlen schwanken in solchen Grenzen, dass man von dem Zusammenhange eines oder des andern Geschlechts mit einer bestimmten Traumaform nicht sprechen kann. Wahrscheinlich unterliegen beide Geschlechter allen Arten von Verletzungen.

Man muss auch noch darauf hinweisen, dass die verschiedenen Arten von Traumata an ein und demselben Individuum gefunden werden, zuweilen kombiniert mit der Anwesenheit der anomalen viergliedrigen Tarsus. Es giebt folgende Trauma-Kombinationen :

Tibio-tarsales und Femoro-trochanter-Trauma;

bei verschiedenen Geschlechtern an verschiedenen Fusspaaren und auf verschiedenen Seiten:

Tibio-tarsales Trauma mit Abbruch von Tarsus-Gliedern (am normalen Tarsus):

bei beiden Geschlechtern an verschiedenen Fusspaaren und auf verschiedenen Seiten;

Femoro-trochanter-Trauma mit Abbruch der Tarsenglieder (am normalen Tarsus):

ebenso;

Tibio-tarsales Trauma mit viergliedrigen Tarsus:

ebenso;

Abbruch der Tarsenglieder (am normalen Tarsus) mit viergliedrigen Tarsus:

ebenso.

Es kommen Traumata einer Art zu gleicher Zeit an mehreren Füssen des Individuums vor (z. B. Femoro-trochanter-Traumata auf der rechten Seite am 2^ten^ und 3^ten^ Paar). Derartiger oben angeführten Kombinationen von verschiedenen Traumaformen mit viergliedrigen Tarsus an einem Individuum an den Füssen verschiedener Paare und Seiten (bei beiden Geschlechtern) zählte ich 39 Fälle bei ♀♀ und 31 Fälle bei ♂♂. Was aber die nicht geschlechtsreifen Individuen angeht, so zählte ich in der Kategorie 15—20 mm. Länge 2 Fälle der oben erwähnten Kombinationen, in der Kategorie 10—15 mm. Länge—im ganzen nur einen Fall.

Wir wollen auch nicht vergessen, dass wir am anomalen viergliedrigen Tarsus ebenfalls Traumata vorfanden : Abbruch von Klauen.

Nach der statistischen Aufstellung von *H. Brindley* und dem vorliegenden Versuche kann man annehmen, wie ich glaube, dass der anomale viergliedrige Tarsus bei *Stylopyga orientalis* (wie bei allen Schaben) als Produkt der Regeneration des normalen fünfgliedrigen Tarsus auftritt, nachdem der Fuss eine Verletzung erlitten, hauptsächlich am Tibio-tarsal- oder Femoro-trochanter-Gelenk, oder nach Abbruch der Tarsenglieder.

Die Frage von den inneren Ursachen eines solchen Verlaufes der Regeneration, wie er bei den *Blattidae* vorkommt, kann ich hier natürlich nicht entscheiden. Das ist schon die Aufgabe des Histologen. Aber ich kann nicht umhin, die Aufmerksamkeit auf die drei oben untersuchten gesetzmässigen Arten von Trauma zu lenken, die am häufigsten im gewöhnlichen Leben der Schabe getroffen werden und als Regenerationsfaktoren dieser vorausgehen; sie verdienen ernste Beachtung auch von Seite des Histologen und um so mehr, als die Frage von den Verletzungen, ihrer Form, Struktur und ihrer Ziffernmässigkeit bis zu dieser Arbeit, soweit mir bekannt, in der Literatur noch nicht angeregt wurde, ausser unbedeutenden Daten, die in Artikeln über Regeneration von Newport und Graber zerstreut sind.

Serpuchow, Januar 1908.

MISCELLANEA.

I. Note on Inheritance of Brachydactyly.

In an addendum to a memoir on "Split Hand and Split Foot Deformities etc." published in *Biometrika*, Vol. VI, Pt. I, 1908, p. 117, the writer, referring to a statement by Punnett to the effect that no member of a brachydactylous family who is free from the defect can transmit it to his or her offspring, stated that this conclusion is disproved by the family recorded by Hasselwander (*Zeitschr. f. Morph. u. Anthrop.* Bd. 6, 1903, S. 510—526), in which such transmission actually occurred. A misprint in the original diagram of the family tree was at the time overlooked, and it appears from a personal communication which the writer has received from Dr Hasselwander, that transmission of the nature stated did not occur.

The remaining two families bearing on the matter under consideration, and quoted in a footnote to the original addendum, may be given in fuller detail. Ammon writes in *Die angebor. chir. Krankh. d. Mensch. u.s.w.* Berlin, 1842, S. 96, as follows:—"Merkwürdig ist in dieser Hinsicht ein von Keltie beobachteter Fall, wo bei den Gliedern einer Familie schon seit zehn Generationen nur der Daumen vollständig gebildet gewesen war, während an den übrigen Fingern entweder beide Gelenke, oder wenigstens das Nagelglied fehlte. Eigenthümlich war dabei, dass sich diese Missbildung nur in den weiblichen Gliedern der Familie fortpflanzte."*

Joachimsthal in *Virchow's Archiv*, Bd. 151, 1898, Folge XV. Bd. 1, S. 430, writes:—"Die 27-jährige, bis auf die zu schildernden Anomalien an beiden Händen normale, 160 cm grosse Patientin weiss über Verbildungen in der Ascendenz nichts zu berichten. Ein 29- und eine 22-jährige Schwester haben, wie sie selbst—wenn auch weniger ausgesprochen—verkürzte Zeige- und Mittelfinger. Der einzige Bruder ist selbst normal gestaltet, besitzt jedoch eine 1-jährige Tochter mit den gleichen Fingerverbildungen, ebenso wie dies bei einem frühzeitig verstorbenen Knaben der älteren Schwester der Fall war. Unsere Patientin selbst ist Mutter eines jetzt 4-jährigen, normalen Knaben. Von den verbildeten Familienmitgliedern habe ich nur die 22-jährige Schwester zu untersuchen vermocht, u.s.w."

In the original addendum the Hasselwander family constituted the most conclusive evidence for the transmission of brachydactylia through a normal individual, and this portion of the evidence must be withdrawn without qualification.

In conclusion, gratitude must be expressed to Mr Punnett for his courtesy in allowing the writer the opportunity of personally correcting the error which has occurred.

July 2, 1908.

THOMAS LEWIS.

II. Note on Inheritance in Man.

The importance of certain considerations being borne in mind with regard to pedigree work is well illustrated by Dr Lewis' note. On looking at Hasselwander's pedigree I personally should consider Dr Lewis' statement correct, not because of the misprint which might attribute some of the children of Fanny to Victoria, a normal individual (for the numbering of the offspring shows that there was a misprint of some sort), but because the writer states directly that the deformed Josepha K. was the child of normal parents.

---

* The original report of the Keltie family has since been found (*Edin. Med. and Surg. Journ.* 1808, Vol. IV. p. 252). The condition was in all probability the same as that in the Farabee family. The women who transmitted the defect were apparently also malformed, though from the text it is somewhat uncertain.

Now it is at this point that a very important consideration comes in. The true Mendelian needs the theory of mutations to supplement his position, and other workers, among whom, I think, I may include Dr Lewis, would say that the deformity started in a sport. Now an experience covering many hundreds of human pedigrees leads me to the conclusion, that the appearance of deformity in the offspring of normal parents with nothing further known of the earlier ancestry is too often only another way of stating that we have not been able to trace fully the ancestral and their collateral lines. In very many cases when I can go back through a normal parentage, I find directly or collaterally the supposed mutation or sport recurring, and we have either to assert (i) that there exists a general tendency to sporting in the stock, or (ii) that the deformity is latent and can be carried through normal individuals. It is needless to say that (ii) appears to me a more scientific assumption. To stop short at a normal pair with the statement 'sport' or 'mutation' is logically incomplete, if we wish to demonstrate that the deformity is handed down only through deformed individuals. We must show for a generation or two in the direct and collateral lines an entire absence of the abnormality.

It is a very general experience that these abnormal cases belong to the lower classes of the population, and that in going back in the pedigree we are invariably checked at but a few generations by ignorance as to blood-relationships. Under such circumstances we must either wind up with an abnormal individual of unknown parentage or with normal individuals as in Dr Hasselwander's or Dr Lewis' cases. My first consideration is that we have not the evidence necessary to speak of the latter as determining a 'sport.'

My second urgent consideration is this: Is not the time ripe for the collection and publication of pedigrees bearing upon normal and abnormal characters in man? There is an immense amount of published material scattered through a wide journalistic area. There is a growing tendency for medical men to record more and more completely family histories*. A collection of published and unpublished material would be of first class value to students of heredity. The primary conditions for such a collection are: (*a*) that it shall contain the material only; no discussion of hereditary theories shall form part of its plan,—this ought to allow of all schools contributing; (*b*) that there shall be no selection of special pedigrees for publication, except on the score of their completeness and the peculiar interest of their characteristics; (*c*) that each contributor should be wholly responsible for the accuracy of his facts and for the genealogies which should be published under his own name. The duty of the Editor should only be to standardise the material received. With a view to providing a collection of this kind, the Galton Laboratory of National Eugenics proposes to issue in parts a *Treasury of Human Inheritance*, each part will contain 20 to 50 pedigrees arranged on 6 to 10 lithographed plates. The individual plates will be devoted to a special characteristic or abnormality. Each pedigree will be accompanied by a brief account of the family and its members, and when needful by an illustration of the characteristic. The *Treasury* will cover published and unpublished material, and there will be an entire absence of any purely theoretical discussions. Full reference will be given to the source of the pedigree and to treatises where similar cases are discussed. The Laboratory has already received promises of help from members of the medical profession, and from officials in asylums, sanitoria and hospitals for special diseases. Is it asking too much to beg our Mendelian friends to give us cooperation in this matter, or at any rate to decide on the basis of the first number whether they cannot do so? The need for such a repertorium must be as manifest to them, as to all other students of heredity, and it would add much to the completeness of our scheme if they did not stand aloof from it. The preparation of material for Part I is well advanced and we hope to issue it in October.

K. P.

---

* Several hundreds of such pedigrees have already reached the Francis Galton Laboratory for National Eugenics.

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CONTENTS

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PAGE

I. Pigmentation Survey of School Children in Scotland.
Committee and Grants 129
Report. By J. F. TOCHER. (With Plates I—XXVI, Table II, and One Diagram in text) 130

II. Variation, Development and Growth in *Holothuria Floridana*, Pourtalès, and in *Holothuria atra*, Jäger. By CHARLES LINCOLN EDWARDS. (With Plates I—V, One Folding Table and Six Diagrams in text) 236

III. Probable Error of a Correlation Coefficient. By STUDENT . . 302

IV. Zur Frage vom vierglieder igen Tarsus der *Blattidae* und der Regeneration der Füsse derselben. Von TH. S. SCHTSCHERBÀKOW . . 311

Miscellanea. (i) Note on Inheritance of Brachydactyly. By THOMAS LEWIS 327

(ii) Note on Inheritance in Man. By K. PEARSON . . 327

Special Supplement to Vol. VI.

Pigmentation Survey of School Children in Scotland. Appendix to the Report. By J. F. TOCHER. (This Appendix gives the classified Returns for all Divisions, Counties and Districts of Scotland, and a complete List of the contributing Teachers) . . . . pp. 1—67

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SOME STATISTICAL OBSERVATIONS ON TERMITES, MAINLY BASED ON THE WORK OF THE LATE MR G. D. HAVILAND.

BY ERNEST WARREN, D.Sc. Lond.

(1) IN the year 1906 Mr A. E. Haviland of Estcourt, Natal, kindly placed at my disposal the collections and notes of the late Mr G. D. Haviland. The latter had made a special study of the termites of Natal and of the Malay Archipelago, and he published a valuable paper on these insects in the *Linnean Society's Journal*, Vol. XXVI. p. 358 *et seq.*, 1897. The notes include some interesting observations on the life-histories of the Natal species of termites, and also a large series of measurements made on one particular species, *Termes natalensis Haviland.* The general biological observations, which appear to be unrecorded, are being incorporated in a short paper which is about to be published in the *Annals of the Natal Government Museum*, while in the present paper the measurements will be briefly dealt with. For the elucidation of some doubtful points, Mr Haviland's observations have been supplemented by some fresh measurements on *Termes natalensis* and also on other species.

As is well known, termites are social insects with an economy bearing some resemblance to that of ants and social bees and wasps. The nature of the inhabitants of a termite-nest varies according to the species and to the season of the year at which examination is made. If a nest of *T. natalensis* be examined in the spring (September) the following different castes may be found: (1) a single *queen* and a single *king*, these are the only sexually mature forms that occur; (2) *soldiers* of two sizes, asexual; (3) *workers* of two sizes, asexual; (4) *winged males* and *females*, not sexually mature; (5) *young or immature members* of castes (2), (3) and (4).

In some species there are several queens and kings in the nest, and the soldiers and workers may be of one size only, or the soldiers may be absent altogether.

In ants and bees the workers (and soldiers, when they occur) are sterile females; while in the termites it appears that both the soldiers and workers are abortive individuals of either sex. There is also evidence for believing that the ultimate fate of the young on hatching is not predetermined, but depends on the subsequent treatment they receive at the hands of the workers. According to this view any given individual on hatching from the eggs may, in the case of *T. natalensis* for example, develop into any one of five distinct forms or castes, which in no way grade into one another, viz. two forms of soldiers, two forms of workers and the winged sexual form. It is certainly most difficult to form a conception on any theory of heredity as to the means by which hereditary characters could be inherited by such a plastic and modifiable organism as the newly hatched young of a termite.

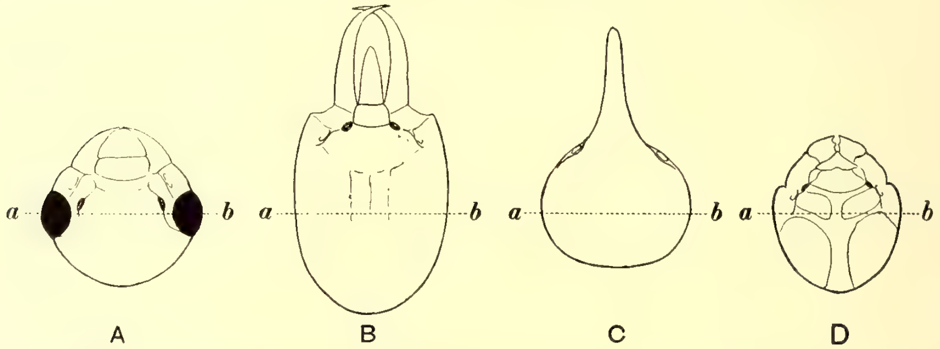
After the first rains the winged sexual forms swarm out of the nest and copulate in the air; they seldom or never appear to return to the parent nest. A pair may succeed in founding a new nest, and will ultimately become the queen and king.

The nest of *T. natalensis* is slow in growing, and it remains inhabited for many years. The same queen and king undoubtedly live for a number of years, and in some species (including *T. natalensis*) it is not known how they are replaced, should they die or an accident befall them.

(2) *The Measurements.*

The measurements were made only on what appeared to be *adult* members of the different castes, except in the case of the winged imagos, when on one occasion nymphs with wing-rudiments were measured. An individual was regarded as *adult* when the exoskeleton of the head was firm and had assumed the characteristic yellow or brown colour. This point is, of course, of considerable importance as there is no sharply marked metamorphosis among termites.

In any case, whether of soldiers, workers or winged imagos, the same dimension was chosen for measurement, viz. the maximum breadth of the head (*ab* in figure below). Owing to the varying configuration of the head in the different castes and species, this dimension in certain cases passes through the compound lateral eyes;



Heads of various castes, viewed from above, showing the line of measurement (*a b*).

A. Imago, *Termes natalensis*. B. Small Soldier, *Termes natalensis*.
C. Large Soldier, *Termes trinervius*. D. Worker, *Termes trinervius*.

and when such occurs it was found that the measurement could be more conveniently and accurately taken if the breadths of the eyes were included in the dimension. It is certain that the inclusion of the eyes in such cases has no appreciable effect on the results, as the correlation of the size of head and eyes is exceedingly close; and the eyes being partially sunk in the exoskeleton complete the contour of the head. It should be noticed that the dimensions taken of the different castes are not perfectly homologous, for some soldiers are blind and others have curiously shaped heads; but they are as nearly homologous as the nature of the case admits, and they may all be regarded as closely comparable measurements.

The measurement of the selected dimension may be made with sufficient accuracy on account of the comparatively rigid nature of the exoskeleton of the head. Length or breadth measurements of the abdomen would have been quite unreliable.

The specimens were in all cases preserved in alcohol.

The method of measurement adopted by Mr Haviland is not recorded in his notes; but I have no hesitation in accepting his data as thoroughly trustworthy. The method which I found most satisfactory was to examine the specimen under an 'aa' or 'AA' Zeiss objective with a camera lucida, and to mark off the dimension on a slip of paper. The termite was flooded with spirit on a slide, and orientated by means of a small piece of glass placed above it. The slip of paper was referred to a scale made with the camera from a stage-micrometer (divided into $\frac{1}{10}$ and $\frac{1}{100}$ mm.) viewed under the same magnification, and the absolute dimension could thus be read off. One or two small series measured by Mr Haviland were re-measured by my method and the results were in close accord.

The measurements of *Termes natalensis* will be first dealt with, and subsequently a comparative review of some of the Natal species of termites will be made.

(3) *Termes natalensis Haviland.*

As we have already seen a colony of this species consists of one queen and king, numerous soldiers of two sizes and workers of two sizes, also immature young or larvæ, and at certain seasons nymphs of males and females, which on becoming winged leave the nest as a swarm.

In the accompanying table the means, standard deviations and coefficients of variation $\left(\frac{\text{Standard Deviation}}{\text{Mean}} \times 100\right)$ of a considerable number of different colonies are shown. The measurements refer chiefly to the soldiers and the workers: where the material was available the queen and king were measured, and in nest No. "653" one hundred male and one hundred female nymphs with wing-rudiments were measured (see Table VIII.).

The nests are arranged in the table according to the season of the year at which the material was collected, beginning with November.

TABLE I.

Termes Natalensis.

Unit=0·01 mm.

Date of Collection	No. of Nest	ROYALTY		LARGE SOLDIERS				SMALL SOLDIERS				LARGE WORKERS				SMALL WORKERS			
		Queen	King	No.	Mean	S. D.	C. of V.	No.	Mean	S. D.	C. of V.	No.	Mean	S. D.	C. of V.	No.	Mean	S. D.	C. of V.
Nov. 7	668	—	—	—	—	—	—	100	227·3	10·20	4·49	86	214·2	5·99	2·79	—	—	—	—
Jan. 18		—	—	3	456·3	—	—	100	233·2	7·61	3·26	85	213·9	7·22	3·37	10	143·4	—	—
Mar. 16		—	—	—	—	—	—	100	237·5	7·40	3·12	89	222·5	4·79	2·15	—	—	—	—
May 16		—	—	3	425·0	—	—	100	237·3	6·91	2·91	100	235·2	7·59	3·23	54	156·7	6·93	4·42
Aug. 23		—	—	—	—	—	—	100	231·8	8·23	3·55	100	226·9	4·66	2·06	—	—	—	—
Nov. 11	670	—	—	4	428·0	—	—	100	247·9	7·05	2·84	100	231·5	7·44	3·22	45	160·3	4·41	2·75
Jan. 18		—	—	46	422·4	13·98	3·31	200	260·3	7·11	2·73	100	246·3	6·07	2·46	—	—	—	—
Mar. 16		—	—	7	441·1	—	—	200	261·3	6·07	2·32	72	248·5	5·45	2·19	—	—	—	—
May 17		—	—	1	434·0	—	—	100	255·7	6·94	2·71	100	247·7	7·02	2·83	14	161·6	—	—
Aug. 25		—	—	5	437·8	—	—	100	237·7	9·23	3·88	100	233·4	6·40	2·74	43	155·4	3·50	2·25
Nov. 12	672	—	—	14	410·6	—	—	100	240·4	13·28	5·52	100	235·9	10·13	4·29	—	—	—	—
Jan. 12		—	—	12	412·0	—	—	100	245·7	7·89	3·21	100	234·4	5·10	2·18	—	—	—	—
Mar. 17		—	—	15	413·7	—	—	100	245·2	6·32	2·58	100	239·4	4·68	1·96	100	157·9	3·62	2·29
May 18		—	—	23	412·0	9·89	2·40	100	239·6	8·78	3·66	100	236·4	5·78	2·44	76	154·6	3·28	2·12
Aug. 28		—	—	8	409·7	—	—	100	227·9	8·48	3·72	100	226·9	5·09	2·24	—	—	—	—
Nov. 16	674	—	—	7	424·6	—	—	100	244·7	7·09	2·90	92	234·9	5·73	2·44	4	158·0	—	—
Jan. 18		—	—	3	421·5	—	—	100	238·8	7·28	3·05	100	230·0	5·82	2·53	4	152·3	—	—
Mar. 17		—	—	10	417·0	—	—	100	251·5	7·08	2·82	100	243·6	4·64	1·91	57	158·2	3·59	2·27
May 20		—	—	—	—	—	—	100	244·5	6·93	2·83	100	242·3	4·93	2·03	38	154·1	2·70	1·75
Aug. 29		—	—	—	—	—	—	100	231·2	7·47	3·23	100	230·2	6·33	2·75	27	150·4	3·02	2·01
Nov. 16	675	—	—	19	419·1	—	—	197	245·6	7·40	3·01	100	236·0	5·65	2·39	68	161·0	4·78	2·97
Jan. 18		—	—	22	415·0	—	—	100	262·6	7·02	2·67	100	247·8	5·96	2·40	5	162·2	—	—
Mar. 17		—	—	7	417·6	—	—	100	263·3	5·94	2·26	100	253·9	4·64	1·83	25	167·9	3·92	2·33
May 29		—	—	3	438·6	—	—	98	248·7	6·94	2·91	100	246·1	5·30	2·15	22	155·3	—	—
Aug. 29		—	—	27	429·0	14·55	3·39	100	241·0	6·88	2·86	100	236·0	7·31	3·10	42	156·4	3·04	1·94

Aug. 20 May 23	620	361 ?	—	37 34	458·8 458·2	14·76 16·13	3·22 3·52	300 842	270·7 271·3	12·57 7·24	4·64 2·67	600 33	255·4 262·5	9·99 5·07	3·91 1·93	— 18	— 165·8	— —	— —
Nov. 12 June 3	630	—	—	187 27	423·7 431·1	12·94 13·20	3·05 3·06	1100 1000	239·0 243·8	8·36 6·59	3·50 2·70	200 32	238·5 248·0	5·40 5·12	2·26 2·06	36 4	156·4 159·0	3·33 —	2·13 —
Nov. ...	676	—	—	10	429·0	—	—	100	229·5	6·91	3·01	74	231·9	6·03	2·60	—	—	—	—
Nov. ...	677	—	—	10	421·6	—	—	100	245·4	6·52	2·66	88	240·5	6·85	2·85	9	162·4	—	—
Nov. ...	678	—	—	—	—	—	—	100	241·6	7·21	2·98	80	233·6	5·19	2·22	45	160·0	3·85	2·40
Nov. ...	679	—	—	6	450·2	—	—	100	233·1	7·72	3·31	100	232·4	4·46	1·92	—	—	—	—
Apr. ...	617	361	absent	219	456·1	12·83	2·81	1600	277·3	7·35	2·65	268	270·9	5·05	1·87	—	—	—	—
May 23	620	361 ?	—	34	458·2	16·13	3·52	842	271·3	7·24	2·67	33	262·5	5·07	1·93	18	165·8	—	—
May 16	668	—	—	3	425·0	—	—	100	237·3	6·90	2·91	100	235·2	7·59	3·23	54	156·7	6·93	4·42
May 17	670	—	—	—	—	—	—	100	255·7	6·94	2·71	100	247·7	7·02	2·83	14	161·6	—	—
May 18	672	—	—	23	412·0	9·89	2·40	100	239·6	8·78	3·66	100	236·4	5·78	2·45	76	154·6	3·28	2·12
May 28	674	—	—	—	—	—	—	100	244·5	6·93	2·83	100	242·3	4·93	2·03	38	154·1	2·70	1·75
May 29	675	—	—	3	438·6	—	—	98	248·7	6·94	2·91	100	246·1	5·30	2·15	22	155·3	—	—
June 3	630	—	—	27	431·1	13·20	3·06	1000	243·8	6·58	2·70	32	248·0	5·12	2·06	4	159·0	—	—
June ...	634	—	—	100	408·5	10·45	2·56	100	233·3	7·76	3·33	—	—	—	—	—	—	—	—
June ...	637	368	362	30	429·2	12·02	2·80	200	247·8	6·50	2·62	36	247·8	6·97	2·81	65	160·4	4·01	2·50
June 20	641	—	—	34	424·7	10·31	2·43	200	242·8	5·92	2·44	49	249·1	5·23	2·10	2	161·0	—	—
June 22	643	—	—	46	424·4	11·78	2·78	100	245·0	6·30	2·57	—	—	—	—	—	—	—	—
June 28	648	—	—	94	453·2	12·72	2·81	100	266·8	7·39	2·77	—	—	—	—	—	—	—	—
June ...	649	—	—	26	450·5	11·83	2·63	300	255·0	6·94	2·72	86	249·6	7·36	2·95	34	158·9	5·12	3·22
June 28	651	352	362	88	445·9	13·18	2·96	200	262·8	7·18	2·73	63	256·9	4·45	1·73	—	—	—	—
June 30	652	373	361	55	469·6	22·64	4·82	200	280·2	9·32	3·33	57	271·6	4·70	1·73	3	169·7	—	—
June ...	653	369	350	213	456·1	15·31	3·36	1100	267·7	9·50	3·55	1100	262·7	8·41	3·20	1100	168·5	5·35	3·18
Aug. 9	654	354	356	38	430·8	16·72	3·88	500	229·5	6·92	3·02	200	230·7	5·88	2·55	35	150·0	3·44	2·29
Aug. 25	657	367	350	34	434·2	12·61	2·90	100	221·7	9·36	4·22	100	233·7	8·87	3·80	47	149·0	3·10	2·08
Sept. 20	658	363	369	8	445·2	—	—	500	235·1	6·54	2·78	500	235·1	6·10	2·60	14	154·4	—	—
Sept. 23	660	366	356	55	438·1	10·98	2·51	200	231·7	13·33	5·72	100	227·6	7·36	3·24	15	155·4	—	—
Sept. 26	661	—	—	22	420·5	—	—	100	227·6	6·37	2·80	100	224·9	5·13	2·28	16	151·5	—	—
Sept. ...	662	—	—	92	413·8	13·92	3·36	100	225·8	5·74	2·54	100	227·5	6·32	2·78	100	154·5	3·01	1·95
Oct. 4	665	362	—	179	418·3	16·66	3·98	100	241·6	7·46	3·09	100	234·9	5·38	2·29	100	159·1	5·51	3·47
Oct. 5	666	366	348	84	421·4	14·11	3·35	100	232·4	6·23	2·68	100	232·6	5·39	2·32	100	156·6	3·72	2·38
Oct. 25	667	367	359	88	439·3	15·46	3·55	300	235·5	6·47	2·75	100	227·4	4·38	1·93	12	154·5	—	—

[Probable errors of means about ·7 and of standard deviations about ·5 for 100 cases. ED.]

(4) *Seasonal Variation.*

Material obtained from the *same* nest at different months exhibited variation in the means and standard deviations. In the first part of Table I. are given the records of seven nests from which material had been collected at different seasons, generally Nov., Jan., Mar., May and August. A comparison of the figures will show that as a rule the mean was lowest and the standard deviation greatest when the material was taken in November, while generally the mean was highest and the standard deviation smallest in the month of March.

In the following table (Table II.) are given the arithmetic means of the means, standard deviations and the coefficients of variation of samples (varying from 72 to 200 in number) of small soldiers and large workers taken from five nests "668," "670," "672," "674," "675" (see Table I.) in the months mentioned above.

TABLE II.

Termes Natalensis.

Month of Collecting	Means of the Five Nests					
	Small Soldiers			Large Workers		
	Mean	Standard Deviation	Coefficient of Variation	Mean	Standard Deviation	Coefficient of Variation
November ...	241·2*	9·00*	3·75	230·5*	6·99*	3·03
January ...	248·1	7·38	2·99	234·5	6·03	2·59
March ...	251·8	6·56	2·62	241·6	4·84	2·01
May ...	245·2	7·30	3·00	241·5	6·12	2·54
August ...	233·9	8·06	3·45	230·7	5·96	2·58

* Unit = ·01 mm.

This seasonal variation probably arises from two causes at least; (1) the elimination of the physically unfit, (2) post "adult" growth. With reference to the first cause it may be noticed that it is very probable that more individuals arrive at maturity from August to November, that is during the first rains, than at other seasons, and therefore the stunted adults will be more abundant during this period, with the result that the mean would be lowered and the standard deviation would be raised. By the time that March arrives the small and weakly individuals of the nest are likely to have died, and consequently the mean will be raised and the standard deviation will be diminished. The second, and perhaps more potent influence, is that the so-called "adults" appear to grow to a certain extent even after their exoskeleton has become hard and yellow. In the following table (Table III.) the frequencies for six nests are given for small soldiers and large workers mostly collected in November and March.

TABLE III.

Termes Natalensis.

Material collected from six nests during November, March and June.

Scale. Unit =0·03 mm.	SMALL SOLDIERS												LARGE WORKERS											
	630		668		670		672		674		675		630		668		670		672		674		675	
	Nov.	June	Nov.	Mar.	Nov.	Mar.	Nov.	Mar.	Nov.	Mar.	Nov.	Mar.	Nov.	June	Nov.	Mar.	Nov.	Mar.	Nov.	Mar.	Nov.	Mar.	Nov.	Mar.
197—199	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
200—202	—	—	1	—	—	—	—	—	—	—	—	—	—	—	4	—	—	—	—	—	—	—	—	—
203—205	—	—	1	—	—	—	—	—	—	—	—	—	—	—	2	—	—	—	—	—	—	—	—	—
206—208	—	—	1	—	—	—	—	—	—	—	—	—	—	—	5	—	—	—	—	—	—	—	—	—
209—211	—	—	3	—	—	—	1	—	—	—	—	—	—	—	19	—	—	—	1	—	—	—	—	—
212—214	—	—	4	—	—	—	2	—	—	—	—	—	—	—	14	2	1	—	0	—	1	—	—	—
215—217	2	—	3	1	—	—	2	—	—	—	—	—	—	—	18	9	0	—	2	—	0	—	—	—
218—220	4	—	6	1	—	—	4	—	—	—	—	—	—	—	14	23	5	—	2	—	1	—	—	—
221—223	21	—	12	1	—	—	5	—	—	—	—	—	—	—	4	20	6	—	8	—	2	—	1	—
224—226	29	3	15	4	1	—	5	—	—	—	1	—	1	—	4	18	10	—	9	1	2	—	4	—
227—229	68	11	8	6	1	—	6	—	1	—	0	—	9	—	1	11	22	—	7	0	7	—	6	—
230—232	115	22	14	12	1	—	4	2	3	—	3	—	15	—	1	2	16	—	9	5	16	1	13	—
233—235	143	75	16	11	2	—	6	3	7	1	10	—	33	—	—	3	13	—	7	11	13	2	25	—
236—238	146	96	7	17	3	—	4	7	6	1	18	—	43	1	—	1	12	—	10	27	26	9	22	—
239—241	168	142	3	19	5	—	8	16	15	7	27	—	42	4	—	—	6	3	14	25	16	22	14	—
242—244	133	209	1	12	14	1	10	20	18	6	32	—	30	3	—	—	5	16	13	18	6	26	5	1
245—247	80	171	1	10	21	0	7	21	15	14	35	—	19	5	—	—	1	17	4	9	2	20	7	6
248—250	81	135	0	2	18	6	8	10	18	19	29	2	5	8	—	—	1	15	8	3	—	13	3	20
251—253	45	69	1	2	16	13	11	12	6	13	13	4	1	7	—	—	1	7	2	0	—	6	—	18
254—256	37	33	1	1	8	24	9	4	5	16	15	6	2	3	—	—	0	7	3	1	—	0	—	26
257—259	19	20	1	1	7	31	3	3	3	9	5	17	—	1	—	—	1	5	0	—	—	1	—	18
260—262	6	9	—	—	0	38	3	1	2	8	4	11	—	—	—	—	—	1	1	—	—	—	—	8
263—265	1	4	—	—	2	40	1	1	1	3	3	23	—	—	—	—	—	0	—	—	—	—	—	2
266—268	2	1	—	—	1	22	1	—	—	2	1	20	—	—	—	—	—	1	—	—	—	—	—	1
269—271	—	—	—	—	—	16	—	—	—	1	1	9	—	—	—	—	—	—	—	—	—	—	—	—
272—274	—	—	—	—	—	7	—	—	—	—	—	6	—	—	—	—	—	—	—	—	—	—	—	—
275—277	—	—	—	—	—	1	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—
278—280	—	—	—	—	—	1	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—
Totals	1100	1000	100	100	100	200	100	100	100	100	197	100	200	32	86	89	100	72	100	100	92	100	100	100

A careful comparison of these frequencies will, I think, lead to the opinion that both of the suggested causes have a share in producing the seasonal variation. The apparent elimination of the small and unfit is best shown in nests "630" and "672" for both the small soldiers and large workers.

(5) *Ratios and Variation of the different Castes.*

Having thus noted the presence of a seasonal variability in a single nest, we may pass to the variability exhibited by a series of colonies. It would, of course, have been preferable to have avoided the disturbing element of the seasonal variation by collecting all material at one season of the year; but this was not done as the presence of a seasonal variation was not suspected.

In the following table (Table IV.) are given the arithmetical means of the means, standard deviations and coefficients of variation of the four castes in a number of nests (see Table I.).

TABLE IV. *Means.*

Caste	Number of Nests*	Mean	Number of Nests †	Standard Deviation	Coefficient of Variation
Large Soldiers ...	23	434·01‡	20	13·64‡	3·12
Small Soldiers ...	30	245·00	30	7·37	3·02
Large Workers ...	27	242·21	27	5·94	2·46
Small Workers ...	19	156·90	12	4·17	2·65
Male Nymphs ...	1	300·05	1	4·71	1·57

There is no overlapping of the large soldiers and small soldiers or of the large workers and small workers; in other words, there was never any question whether any individual should be classed amongst the "large" or "small" series.

With reference to the particular dimension measured there is overlapping between the small soldiers and large workers; but the soldiers and workers are totally distinct in general structure and shape.

Ratios.

$$\frac{\text{Mean of Small Soldiers}}{\text{Mean of Large Soldiers}} \times 100 = \frac{245{\cdot}001}{434{\cdot}013} \times 100 = 56{\cdot}4,$$

and

$$\frac{\text{Mean of Small Workers}}{\text{Mean of Large Workers}} \times 100 = \frac{156{\cdot}901}{242{\cdot}206} \times 100 = 64{\cdot}8.$$

Thus, in the proportion in size that occurs between the "large" and "small" classes, the soldiers and workers approach each other; the "small" class being more than half the size of the "large" class.

$$\frac{\text{Mean of Large Workers}}{\text{Mean of Large Soldiers}} \times 100 = \frac{242{\cdot}206}{434{\cdot}013} \times 100 = 55{\cdot}8,$$

and

$$\frac{\text{Mean of Small Workers}}{\text{Mean of Small Soldiers}} \times 100 = \frac{156{\cdot}901}{245{\cdot}001} \times 100 = 64{\cdot}0.$$

* Nests from which less than 10 individuals were available are here excluded.

† Only nests from which more than 23 individuals were available are included.

‡ Unit = 0·01 mm.

Thus it will be seen that the workers are more than double the size of the soldiers of the similarly sized class.

The variability of the soldiers, as measured by the coefficient of variation, is greater than that of the workers, the ratios being:

$$\frac{\text{Coefficient of Large Workers}}{\text{Coefficient of Large Soldiers}} \times 100 = \frac{2{\cdot}461}{3{\cdot}123} \times 100 = 78{\cdot}8,$$

$$\frac{\text{Coefficient of Small Workers}}{\text{Coefficient of Small Soldiers}} \times 100 = \frac{2{\cdot}647}{3{\cdot}022} \times 100 = 87{\cdot}6,$$

that is the workers are about 0·8 times as variable as the soldiers.

(6) *General Variability of the sexual and asexual Castes.*

The average coefficient of variation for the four castes is 2·8: it is thus seen that the general variability of these termite-castes is distinctly small. The nymphs of the winged sexual forms appear to exhibit extraordinarily little variation. In the case of 100 male and 100 female nymphs (Table VIII. nest "653") the coefficients were only 1·57 and 1·60 respectively. Unfortunately there is no available material for ascertaining the variability of the adult sexual form before leaving the nest in the species *natalensis*; but, as will be seen later, small series of winged imagos have been measured in some of the other species, and there is a general tendency towards a low variability.

It has been remarked that there appears to be good evidence for supposing that the young which hatch from the eggs are all alike, and that by special feeding, or by some manipulation by the workers, any one of the five castes may be produced. From this it would be expected that the variability exhibited by all the castes would be about the same; but it has been shown above that the workers are less variable than the soldiers, and that the asexual castes generally are much less variable than the sexual castes. In this connexion, it should be remembered that the individuals in a nest are all produced from one queen and king. The difference in the variability of the castes must therefore be referred to differences in food or other environmental conditions, since they all have a common parentage, and are presumably all alike on hatching.

Thus, the tendency to vary is induced or modified by the special food or manipulation received, and the influences necessary for the production of a soldier or worker lead to greater variability than those for the formation of a sexual imago. It appears that either sex may be converted into either soldiers or workers, the potential sex having no effect on the ultimate destiny of the individual. It is clear that the environment has an overwhelming effect on these organisms, it influences the variability and decides on the bodily shape and structure of the developing insect.

(7) *Comparison of the Constants of a Family with those of the Population.*

Of small soldiers, random samples from 30 nests were measured. The sizes of the samples were most disproportionate, ranging from 100 to 1600. On adding

TABLE V.

Termes Natalensis Haviland, Small Soldiers; 30 *nests,* 100 *from each.*

No. of Nest	*617*	*634*	*637*	*641*	*643*	*648*	*649*	*651*	*652*	*653*	*630*	*654*	*657*	*658*	*660*	*661*	*662*	*665*	*666*	*667*	*630*	*668*	*670*	*672*	*674*	*675*	*676*	*677*	*678*	*679*	Totals	
Month	April	June	June	June	June	June	June	June	June	July	Aug.	Aug.	Aug.	Sept.	Sept.	Sept.	Sept.	Oct.	Oct.	Oct.	Nov.	Nov.	Nov.	Nov.	Nov.	Nov.	Nov.	Nov.	Nov.	Nov.		
*197—199**	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	1	2
200—202	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	1	
203—205	—	—	—	—	—	—	—	—	—	—	—	—	3	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	4	7
206—208	—	—	—	—	—	—	—	—	—	—	—	—	2	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	3	
209—211	—	—	—	—	—	—	—	—	—	—	—	—	7	—	—	1	—	—	—	—	—	3	—	1	—	—	—	—	—	—	12	30
212—214	—	—	—	—	—	—	—	—	—	—	—	—	9	—	1	0	1	—	—	—	—	4	—	2	—	—	—	—	—	1	18	
215—217	—	1	—	—	—	—	—	—	—	—	—	3	13	—	4	3	7	—	—	—	—	3	—	2	—	—	4	—	—	0	40	121
218—220	—	4	—	—	—	—	—	—	—	—	—	5	16	1	8	10	12	—	3	2	1	6	—	4	—	—	5	—	—	4	81	
221—223	—	8	—	—	—	—	—	—	—	—	—	11	11	2	8	14	15	—	3	7	3	12	—	5	—	—	6	1	1	5	112	289
224—226	—	9	—	1	—	—	—	—	—	—	—	29	13	8	19	18	18	—	8	7	3	15	1	5	—	—	11	1	1	10	177	
227—229	—	9	—	1	1	—	1	—	—	—	1	15	10	15	21	13	21	4	22	7	4	8	1	6	1	—	13	2	1	10	187	396
230—232	—	12	2	2	2	—	0	—	—	—	1	19	3	16	5	16	12	6	21	16	9	14	1	4	3	1	20	3	5	16	209	
233—235	—	18	4	5	2	—	1	—	—	—	4	10	7	18	8	13	10	14	13	18	18	16	2	6	7	6	16	7	12	20	255	458
236—238	—	14	2	8	6	—	5	—	—	—	6	3	1	22	3	8	3	13	10	14	10	7	3	4	6	9	13	9	13	11	203	
239—241	—	9	7	27	16	—	3	—	—	—	13	2	2	10	1	4	1	12	11	10	15	3	5	8	15	11	7	12	17	10	231	464
242—244	—	6	14	15	24	—	7	1	—	—	7	1	2	5	1	—	—	19	6	10	13	1	14	10	18	18	3	17	13	8	233	
245—247	—	8	16	20	16	—	5	1	—	1	11	0	0	2	2	—	—	9	3	6	6	1	21	7	15	19	0	21	22	3	215	385
248—250	—	2	20	12	12	1	6	4	—	2	7	0	0	1	3	—	—	13	—	2	7	0	18	8	18	11	1	14	7	1	170	
251—253	—	—	13	3	13	1	14	9	—	3	4	0	0	—	4	—	—	4	—	0	1	1	16	11	6	7	1	9	2	0	122	248
254—256	—	—	12	5	5	10	17	8	2	5	8	0	0	—	6	—	—	3	—	1	5	1	8	9	5	9	—	3	4	0	126	
257—259	—	—	6	1	2	6	8	15	2	7	5	0	0	—	2	—	—	1	—	—	3	1	7	3	3	3	—	0	0	0	75	145
260—262	—	—	2	—	1	11	18	8	2	10	7	0	1	—	1	—	—	1	—	—	0	—	0	3	2	2	—	1	0	0	70	
263—265	—	—	2	—	—	12	4	25	2	18	6	1	—	—	2	—	—	1	—	—	1	—	2	1	1	3	—	—	2	1	84	136
266—268	2	—	—	—	—	14	7	7	5	9	5	0	—	—	0	—	—	—	—	—	1	—	1	1	—	0	—	—	—	—	52	
269—271	14	—	—	—	—	15	1	8	8	12	4	1	—	—	0	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	64	144
272—274	19	—	—	—	—	17	2	8	10	17	6	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	80	
275—277	9	—	—	—	—	9	1	2	3	6	5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	35	81
278—280	21	—	—	—	—	3	—	3	13	6	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	46	
281—283	15	—	—	—	—	0	—	1	14	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	32	51
284—286	6	—	—	—	—	0	—	—	13	0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	19	
287—289	8	—	—	—	—	0	—	—	10	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	19	28
290—292	1	—	—	—	—	1	—	—	7	0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	9	
293—295	3	—	—	—	—	—	—	—	4	0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	7	13
296—298	2	—	—	—	—	—	—	—	4	0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	6	
299—301	—	—	—	—	—	—	—	—	0	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1
	—	—	—	—	—	—	—	—	0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0	
302—304	—	—	—	—	—	—	—	—	0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0	0
	—	—	—	—	—	—	—	—	0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0	
305—307	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1

* Unit = 0·03 mm.

all together there is obtained a population of 8497 individuals derived from 30 different nests.

The constants are: Mean 251·8, Standard Deviation 19·86, Coefficient of Variation 7·89.

The distribution of the frequencies is irregular, and the polygon shows a well-marked double peak. The cause of this is chiefly attributable to the great disproportion of the size of the samples, and the consequent undue influence of one or two individual nests. To avoid this disturbing effect, random samples of 100 individuals from each of the 30 nests were taken. In this way there results a population of 3000 (Table V.), and the constants are: Mean 243·5, Standard Deviation 17·08, Coefficient of Variation 7·02. The distribution of the frequencies is much less irregular than in the former case, and the polygon is consequently much smoother.

The coefficient of variation of the population of 3000 is thus 7·02 as compared with the mean value of 3·02 for the families. In other words the variability of the family of small soldiers is about 43 °/ₒ of that for the population. The variability of the population compared with the fraternal variability is much higher than was expected, judging from the value obtained from certain breeding experiments with a moth, *S. clathrata,* conducted several years ago at University College, London. The cause would appear to be attributable to the great effect of the environment on the means and variabilities of the different castes of a nest.

(8) *Correlation of the Means.*

The correlation between the means of the small soldiers and large workers has been determined in the case of the 27 nests entered in Table I. The correlation-surface is shown in the following table. The calculated constants are: mean of means of small soldiers, 244·3 units, standard deviation, 15·29; large workers, 241·4 units and 13·04 respectively.

Correlation coefficient = ·953, probable error ± ·012.

For the calculation of the correlation between the large soldiers and small soldiers only 20 nests were available.

The constants are: Large soldiers, mean of means, 435·5 units, standard deviation, 16·9; small soldiers, 247·3 units and 17·14 respectively.

Coefficient of correlation = ·831, probable error = ± ·046.

Since the probable error is so considerable, there is no reason for supposing that the correlation between the large and small soldiers differs appreciably from that between the small soldiers and the large workers, which we found to be ·953 ± ·012. It may be assumed that the correlation of the means between any two castes is about ·9. It is curious that the correlation between similar castes (large and small soldiers) does not appear to be greater than that between dissimilar castes (small soldiers and large workers).

TABLE VI.

Termes Natalensis Haviland.

Correlation of the Means of Small Soldiers and Large Workers from 27 nests.*

Small Soldiers Unit = 0·04 mm.	4	2	7	1	2	4	2	0	1	2	0	2	27
221—224	—	—	1	—	—	—	—	—	—	—	—	—	1
225—228	2	—	—	—	—	—	—	—	—	—	—	—	2
229—232	1	2	1	—	—	—	—	—	—	—	—	—	4
232—236	1	0	2	—	—	—	—	—	—	—	—	—	3
237—240	—	—	1	1	—	—	—	—	—	—	—	—	2
241—244	—	—	2	0	1	1	1	—	—	—	—	—	5
245—248	—	—	—	—	1	2	—	—	—	—	—	—	3
249—252	—	—	—	—	—	—	—	—	—	—	—	—	0
253—256	—	—	—	—	—	1	1	—	—	—	—	—	2
257—260	—	—	—	—	—	—	—	—	—	—	—	—	0
261—264	—	—	—	—	—	—	—	—	1	—	—	—	1
265—268	—	—	—	—	—	—	—	—	—	1	—	—	1
269—272	—	—	—	—	—	—	—	—	—	1	—	—	1
273—276	—	—	—	—	—	—	—	—	—	—	—	—	0
277—280	—	—	—	—	—	—	—	—	—	—	—	2	2
Large Workers Unit = 0·04 mm.	*224—227*	*228—231*	*232—235*	*236—239*	*240—243*	*244—247*	*248—251*	*252—255*	*256—259*	*260—263*	*264—267*	*268—271*	

(9) *Standard Deviation of the Means.*

The standard deviation of the means of the large soldiers for random samples taken from 20 nests is 16·90, for small soldiers from 27 nests 15·29, and for large workers from 27 nests, 13·04. It is thus seen that the means of different nests vary very considerably, and reference to Table I. will show that this variation is not entirely or even mainly due to the fact that the material was not all collected at the same time of the year. We have here to do with the effect of inheritance, or with that of the slightly different environment of each nest. It will be noticed that the standard deviations of the means for the three castes are all of the same order of magnitude, although that for the large workers is the lowest.

(10) *Correlation of the Coefficients of Variation.*

The variability of the members of a nest varies in different nests; thus the standard deviation of the coefficients of variation of random samples of small soldiers taken from 27 nests is 4·42 units, and of large workers 3·40 units. The coefficient of correlation between the coefficients of variation of small soldiers and large workers in 27 nests is ·453; but the probable error is ± ·103, which is so great that it is scarcely safe to conclude that we have this correlation very closely.

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* The smallest number of individuals from a nest was 32.

TABLE VII.

Termes Natalensis Haviland.

Correlation of the Coefficients of Variation of Small Soldiers and Large Workers from 27 nests.

Small Soldiers Unit=0·15	3	3	4	4	1	3	0	4	1	2	1	0	0	1	27
244—258	—	—	1	—	—	—	—	1	—	—	—	—	—	—	2
259—273	2	1	1	1	0	0	0	3	1	—	—	—	—	—	9
274—288	—	1	1	1	0	1	—	—	—	—	—	—	—	—	4
289—303	—	—	1	1	0	2	0	0	0	1	—	—	—	—	5
304—318	—	—	—	1	—	—	—	—	—	—	—	—	—	—	1
319—333	1	1	—	—	—	—	—	—	—	—	—	—	—	—	2
334—348	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0
349—363	—	—	—	—	—	—	—	—	—	1	—	—	—	—	1
364—378	—	—	—	—	1	—	—	—	—	—	—	—	—	—	1
379—393	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0
394—408	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0
409—423	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1
....	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
564—578	—	—	—	—	—	—	—	—	—	—	1	—	—	—	1
Large Workers Unit=0·15	*173—187*	*188—202*	*203—217*	*218—232*	*233—247*	*248—262*	*263—277*	*278—292*	*293—307*	*308—322*	*323—337*	*338—352*	*353—367*	*368—382*	

A correlation table of the coefficients of variation of large soldiers and small soldiers was prepared; but without actual calculation it was obvious that there was practically no correlation present.

From this we gather that in any given nest when one caste happens, say, to be particularly variable, it does not follow that every other caste is correspondingly variable. From *à priori* reasons one would have expected that the variability of the different castes in a nest would have been closely related, if the variability is to be regarded as an inherited character. If, on the other hand, the variability is to be mainly referred to nurture or to the general environmental conditions, the above results are intelligible.

(11) *Comparison of various Species.*

In Table VIII. are given the means, standard deviations and the coefficients of variation of the different castes for all the more commonly occurring Natal termites.

TABLE VIII. *Constants of a Series*

Name of Species	No. of Nest	Locality and Date	Large Soldiers				Small Soldiers			
			No.	Mean	Standard Deviation	Coefficient of Variation	No.	Mean	Standard Deviation	Coefficient of Variation
Hodotermes havilandi, Sharpe	635	Natal, Altitude 3000 ft. June 26, 1898	51	421·4	24·46	5·80	None found			
	636	Natal, Altitude 3000 ft. June 27, 1898	—	—	—	—				
	—	Hlabisa, Zululand, June 25, 1903	—	—	—	—				
Calotermes durbanensis, Haviland	601 & 602	Durban, Feb. 15, 1898	80	178·3	4·45	2·49	None occur			
	608	Durban, Feb. 15, 1898	—	—	—	—				
Termes natalensis, Haviland	653	Natal, Altitude 3500 ft. July 1898	213	456·6	15·31	3·36	1100	267·7	9·50	3·55
Termes badius, Haviland	626	Natal, 1894	124	288·75	10·26	3·55	—	—	—	—
	625	Natal, 1894	—	—	—	—	7	229·0	—	—
Termes latericius, Haviland	647	Slievrye, Estcourt, Natal, June 25, 1898	500	137·4	3·86	2·81	None occur			
Termes vulgaris, Haviland	624	Natal, Altitude 4000 ft. May 28, 1898	500	156·2	3·97	2·55	None occur			
	628	Natal, Altitude 4000 ft. June 1, 1898	—	—	—	—				
Termes incertus, Hagen	629	Natal, Altitude 4000 ft. June 1, 1898	47	76·2	2·25	2·95	None occur			
	Taken from one nest	Natal	—	—	—	—				
Termes parvus, Haviland	633	Natal, Altitude 3600 ft. June, 1898	25	83·4	2·62	3·14	None occur			
	Swarm	Slievrye, Estcourt, Natal, March 30, 1899	—	—	—	—				
	644	Natal, Altitude 3800 ft. June 23, 1898	50	82·7	2·12	2·56				
Termes bilobatus, Haviland	621	Natal, Altitude 3500 ft. May 26, 1898	57	148·1	2·81	1·90	None occur			
	623	Natal, Altitude 3500 ft. May 26, 1898	21	151·8	—	—				
	632	Natal, Altitude 3600 ft. June 15, 1898	25	147·5	2·60	1·76				
	Swarm	Natal, Oct. 24, 1898 ...	—	—	—	—				
	639	Natal, Altitude 3500 ft. June 17	20	148·8	—	—				
	640	Natal, Altitude 3500 ft. June 18	27	147·5	2·74	1·86				
	—	Natal, 1894	—	—	—	—				
	615	Natal, Altitude 5500 ft. April 5	—	—	—	—				
Termes trinervius, Rambur	—	Town Bush, Pietermaritzburg, April 20, 1907	64	142·3	6·23	4·38	70	89·8	3·58	3·99
	Taken from one nest	Natal, Oct. 19, 1898 ...	—	—	—	—	—	—	—	—
	—	Park, Maritzburg, Sept. 15, 1908	—	—	—	—	—	—	—	—
Rhinotermes Sp.	603	Durban, Feb. 1898	93	187·5	6·06	3·23	91	92·04	3·23	3·51

of Species. Unit = 0·01 mm.

LARGE WORKERS				SMALL WORKERS				MALES				FEMALES			
No.	Mean	Standard Deviation	Coefficient of Variation	No.	Mean	Standard Deviation	Coefficient of Variation	No.	Mean	Standard Deviation	Coefficient of Variation	No.	Mean	Standard Deviation	Coefficient of Variation
43	360·3	15·45	4·29	50	237·3	14·34	6·05	—	—	—	—	—	—	—	—
50	380·8	13·71	3·60	34	268·9	12·79	4·76	—	—	—	—	—	—	—	—
12	386·2	—	—	16	278·5	—	—	—	—	—	—	—	—	—	—
—	—	—	—	None occur				—	—	—	—	—	—	—	—
50	149·8	7·42	4·95					—	—	—	—	—	—	—	—
								Nymphs with wing-rudiments				Nymphs with wing-rudiments			
1100	262·7	8·41	3·20	1100	168·5	5·35	3·18	100	300·1	4·71	1·57	100	298·4	4·78	1·60
50	187·1	8·16	4·36	50	132·2	5·74	4·34	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
100	177·9	5·68	3·20	51	112·9	4·88	4·32	—	—	—	—	—	—	—	—
55	156·8	4·40	2·81	100	110·5	2·41	2·19	—	—	—	—	—	—	—	—
								Winged imagos				Winged imagos			
—	—	—	—	—	—	—	—	34	261·7	6·16	2·35	33	262·3	6·92	2·64
50	88·2	3·13	3·55	None found				—	—	—	—	—	—	—	—
								Winged imagos				Winged imagos			
—	—	—	—					35	134·2	2·71	2·02	32	135·9	2·93	2·15
28	77·2	3·67	4·76	None occur				—	—	—	—	—	—	—	—
								Winged imagos				Winged imagos			
—	—	—	—					30	113·0	3·09	2·73	25	119·9	1·94	1·62
—	—	—	—					—	—	—	—	—	—	—	—
—	—	—	—	None occur				—	—	—	—	—	—	—	—
—	—	—	—					—	—	—	—	—	—	—	—
20	105·1	—	—					—	—	—	—	—	—	—	—
								Winged Imagos				Winged imagos			
—	—	—	—					50	112·9	1·71	1·52	43	120·4	2·40	1·99
—	—	—	—					—	—	—	—	—	—	—	—
—	—	—	—					—	—	—	—	—	—	—	—
29	95·1	2·28	2·40					—	—	—	—	—	—	—	—
36	94·6	2·83	2·99					—	—	—	—	—	—	—	—
160	166·4	11·42	6·86	None occur				—	—	—	—	—	—	—	—
								Winged imagos				Winged imagos			
—	—	—	—					26	193·8	4·18	2·16	46	192·4	3·69	1·92
100	165·9	7·73	4·66					—	—	—	—	—	—	—	—
36	144·4	7·79	1·93	Stated to occur, but no specimens				—	—	—	—	—	—	—	—

TABLE VIII. *Constants of a Series of Species.* Unit = 0·01 mm.

Name of Species	No. of Nest	Locality and Date	Large Soldiers				Small Soldiers				Large Workers				Small Workers				Males				Females			
			No.	Mean	Standard Deviation	Coefficient of Variation	No.	Mean	Standard Deviation	Coefficient of Variation	No.	Mean	Standard Deviation	Coefficient of Variation	No.	Mean	Standard Deviation	Coefficient of Variation	No.	Mean	Standard Deviation	Coefficient of Variation	No.	Mean	Standard Deviation	Coefficient of Variation
Hodotermes havilandi, Sharpe	635	Natal, Altitude 3000 ft. June 26, 1898	51	421·4	24·46	5·80	None found				43	360·3	15·45	4·29	50	237·3	14·34	6·05	—	—	—	—			—	—
	636	Natal, Altitude 3000 ft. June 27, 1898	—	—	—	—					50	380·8	13·71	3·60	34	268·9	12·79	4·76	—	—	—	—	—	—	—	—
	—	Hlabisa, Zululand, June 25, 1903	—	—	—	—					12	386·2	—	—	16	278·5	—	—	—	—	—	—	—	—	—	
Calotermes durbanensis, Haviland	601 & 602	Durban, Feb. 15, 1898	80	178·3	4·45	2·49	None occur				—	—	—	—	None occur				—	—	—	—	—	—	—	—
	608	Durban, Feb. 15, 1898	—	—	—	—					50	149·8	7·42	4·95					—	—	—	—	—	—	—	—
Termes natalensis, Haviland	653	Natal, Altitude 3500 ft. July 1898	213	456·6	15·31	3·36	1100	267·7	9·50	3·55	1100	262·7	8·41	3·20	1100	168·5	5·35	3·18	Nymphs with wing-rudiments 100	300·1	4·71	1·57	Nymphs with wing-rudiments 100	298·4	4·78	1·60
Termes badius, Haviland	626	Natal, 1894	124	288·75	10·26	3·55	—	—	—	—	50	187·1	8·16	4·36	50	132·2	5·74	4·34	—	—	—	—	—			—
	625	Natal, 1894	—	—	—	—	7	229·0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Termes latericius, Haviland	647	Slievrye, Estcourt, Natal, June 25, 1898	500	137·4	3·86	2·81	None occur				100	177·9	5·68	3·20	51	112·9	4·88	4·32	—	—	—	—	—	—	—	—
Termes vulgaris, Haviland	624	Natal, Altitude 4000 ft. May 28, 1898	500	156·2	3·97	2·55	None occur				55	156·8	4·40	2·81	100	110·5	2·41	2·19	—	—			—	—		—
	628	Natal, Altitude 4000 ft. June 1, 1898	—	—	—	—					—	—	—	—	—	—	—	—	Winged imagos 34	261·7	6·16	2·35	Winged imagos 33	262·3	6·92	2·64
Termes incertus, Hagen	629	Natal, Altitude 4000 ft. June 1, 1898	47	76·2	2·25	2·95	None occur				50	88·2	3·13	3·55	None found				—	—				—	—	—
	Taken from one nest	Natal	—	—	—	—					—	—	—	—					Winged imagos 35	134·2	2·71	2·02	Winged imagos 32	135·9	2·93	2·15
Termes parvus, Haviland	633	Natal, Altitude 3600 ft. June, 1898	25	83·4	2·62	3·14	None occur				28	77·2	3·67	4·76	None occur				—	—	—	—	—	—		—
	Swarm	Slievrye, Estcourt, Natal, March 30, 1899	—	—	—	—					—	—	—	—					Winged imagos 30	113·0	3·09	2·73	Winged imagos 25	119·9	1·94	1·62
	644	Natal, Altitude 3800 ft. June 23, 1898	50	82·7	2·12	2·56					—	—	—	—					—	—	—	—	—	—		—
Termes bilobatus, Haviland	621	Natal, Altitude 3500 ft. May 26, 1898	57	148·1	2·81	1·90	None occur				—	—	—	—	None occur				—	—			—	—	—	—
	623	Natal, Altitude 3500 ft. May 26, 1898	21	151·8	—	—					—	—	—	—					—		—	—	—	—		—
	632	Natal, Altitude 3600 ft. June 15, 1898	25	147·5	2·60	1·76					20	105·1	—	—					—	—	—	—	—	—		—
	Swarm	Natal, Oct. 24, 1898 ...	—	—	—	—					—	—	—	—					Winged Imagos 50	112·9	1·71	1·52	Winged imagos 43	120·4	2·40	1·99
	639	Natal, Altitude 3500 ft. June 17	20	148·8	—	—					—	—	—	—					—	—			—	—	—	—
	640	Natal, Altitude 3500 ft. June 18	27	147·5	2·74	1·86					—	—	—	—					—	—	—	—	—	—	—	—
	—	Natal, 1894	—	—	—	—					29	95·1	2·28	2·40					—	—	—	—	—		—	—
	615	Natal, Altitude 5500 ft. April 5		—		—					36	94·6	2·83	2·99					—	—	—	—	—		—	—
Termes trinervius, Rambur		Town Bush, Pietermaritzburg, April 20, 1907	64	142·3	6·23	4·38	70	89·8	3·58	3·99	160	166·4	11·42	6·86	None occur				—	—	—	—	—	—	—	—
	Taken from one nest	Natal, Oct. 19, 1898 ...	—	—	—	—	—	—	—	—	—	—	—	—					Winged imagos 26	193·8	4·18	2·16	Winged imagos 46	192·4	3·69	1·92
	—	Park, Maritzburg, Sept. 15, 1908	—	—	—	—	—	—	—	—	100	165·9	7·73	4·66					—	—	—	—	—	—	—	—
Rhinotermes Sp.	603	Durban, Feb. 1898	93	187·5	6·06	3·23	91	92·04	3·23	3·51	36	144·4	7·79	1·93	Stated to occur, but no specimens				—	—	—	—	—	—	—	—

TABLE IX.

Ratios of Means × 100.

Species	Small Soldiers / Large Soldiers	Small Workers / Large Workers	Large Workers / Small Soldiers	Small Workers / Large Soldiers	Small Workers / Small Soldiers	Large Workers / Small Soldiers	Workers / Male Imagos
Hodotermes havilandi ...	—	65·8	85·5	56·3	—	—	—
Calotermes durbanensis	—	—	84·0	—	—	—	—
Termes natalensis ...	58·7	64·2	57·6	37·0	63·0	98·1	—
Termes badius ...	79·3	70·7	64·8	45·8	73·6	81·7	—
Termes latericius ...	—	63·5	129·5	82·2	—	—	—
Termes vulgaris ...	—	70·5	100·4	70·7	—	—	60·0
Termes incertus ...	—	—	115·7	—	—	—	65·7
Termes parvus	—	—	92·6	—	—	—	68·3
Termes bilobatus ...	—	—	64·0	—	—	—	84·0
Termes trinervius ...	63·1	—	116·9	—	—	185·3	85·9
Rhinotermes	49·1	—	77·0	—	—	156·9	—
Means	62·5	66·9	89·8	58·4	68·3	130·5	72·8

Relative Sizes of the various Castes.—Ratios.

Soldiers of two sizes occur in *Termes natalensis, Termes badius, Termes trinervius* and *Rhinotermes sp.*, and the ratios are given in the 2nd column of Table IX. There is considerable variation in the ratios, and the mean is 62·5.

Two sizes of workers occur in five species. It should be noticed that it does not follow that there are two sizes of soldiers when there are two castes of workers and *vice versa*. The ratios are given in the 3rd column of Table IX. It will be seen that they are fairly constant, the mean (66·9) is somewhat similar to that for the soldiers (62·5).

The ratios of large workers to large soldiers are given in the 4th column of the table and they are exceedingly variable, ranging from 57·6 in *Termes natalensis* to 129·5 in *Termes latericius*.

Various other ratios are given in the remaining columns of the table, and there is no marked tendency for constancy in any of them; although the ratio of workers to winged imagos is less variable than the others.

Means of the Coefficients of Variation.

The arithmetic mean of the coefficients for large soldiers for the 11 species (see Table VIII.) is 3·26; for small soldiers (3 species) 3·68; for large workers (11 species) 3·74; for small workers (5 species) 3·89; for male imagos (6 species) 2·06; and for female imagos 1·98.

It is evident from these results that the male and female imagos are considerably less variable than any of the asexual castes. The special manipulation, whether of the nature of specialised food or of any other influence, necessary for the production of these castes, appears to increase the variability.

With regard to the variability of the asexual castes, it will be noticed that the mean results for the series of species are not in accord with those for the species *Termes natalensis*. In this species the soldiers were more variable than the workers, but in the mean values for all the species the reverse is the case.

(12) *Comparison of the termite measurements with those of Wasps.*

Miss Alexandra Wright, Dr Alice Lee and Professor Karl Pearson have recently completed an investigation on the variability of various parts of the wings of worker, drone and queen wasps (*Biometrika*, Vol. v. Part IV. p. 407, 1907). The material employed comprised the individuals from *one* large nest, and it will be of interest to compare as far as possible the results obtained with those from the termites.

In the absolute dimensions the queens, drones and workers of the wasps are in descending order of magnitude with respect to the wing-measurements.

In the case of the termites, the means of the head-breadths of the five species (*T. vulgaris, T. incertus, T. parvus, T. bilobatus* and *T. trinervius*) were for male imagos, 163·15 units; workers, 117·3 and soldiers, 121·3. Thus, although the dimensions measured are of a different nature, the wasps and termites agree in the sexual forms being the larger.

The absolute variation in the wasps is greater for the workers than for the drones and queens. In the case of the five species of termites, the workers have a mean absolute variation of 4·67 units against 3·51 for the soldiers and 3·57 for the male imagos; that is, a mean of 4·09 for the asexual castes against 3·57 for the sexual form. The general tendency is consequently for the termites and wasps to resemble each other in this matter.

In the relative variabilities (coefficients of variation) the sexual forms (drones and queens) of the wasps are considerably less variable than the workers, the means being: workers, 3·55; drones, 2·60; queens, 1·57.

In the termites the means are, as we have already seen, for: large soldiers, 3·26; small soldiers, 3·68; large workers, 3·74; small workers, 3·89; male imagos, 2·06; female imagos, 1·99.

There is thus a very striking similarity in these results: the mean of the coefficients for drone and queen wasps is 2·08, and for male and female imagos of the termites 2·02.

The asexual wasp caste of workers with a coefficient of 3·55 also compares very closely with the mean of the coefficients of the asexual termite castes, 3·64.

The material at the disposal of the authors of the wasp paper did not permit of the examination of the correlation of the different castes in a number of nests, and consequently a comparison on this point with the termites cannot be instituted *.

(13) *Summary of some of the Results.*

(1) Although the young appear to hatch all alike and in certain species (*T. natalensis*, for example) all are the offspring of one queen and king, yet the various asexual and sexual castes of a nest exhibit marked differences in their variabilities. The differences in the variability cannot therefore be regarded as due to inheritance, but must be supposed to arise mainly through post-embryonic environmental influences.

(2) The sexual caste is much less variable than the asexual castes.

(3) The relative variability (measured by the coefficient of variation) of the population compared with that of a family (the individuals of a nest) appears to be considerably greater than can be accounted for from the ordinary effects of inheritance †, and the cause is almost certainly to be found in the moulding influence of a varying environment on an exceedingly plastic organism.

[* The relative variability of the species and of the members of a nest is now being investigated and the results will shortly be published. Ed.]

[† The reduction in variability for the case of *assortative mating* of a large amount has not yet been worked out. For the termites we have in each generation a brother-sister marriage, or an assortative mating, say of ·5. There is thus only one pair of ancestors in each generation, and the reduction of variability for such a system may quite conceivably be as great as that indicated by the termite measurements, i.e. nest variability 7·37 and general population variability 17·08. Ed.]

(4) The correlation of the means of any two castes in a nest of a population of colonies is of very considerable magnitude, being about ·9. In other words when, for example, the mean of one caste is above the average, then the mean of any other caste in the nest is correspondingly high. Leaving out the effect of inheritance, this correlation could be accounted for by the fact that similar environmental influences would act on all the members of a nest.

(5) The standard deviations of the means of different castes in a population of colonies are considerable; and there is little doubt that the varying environment of each colony is largely responsible for the great fluctuations in the means.

(6) The correlation of the coefficients of variation of any two castes in a population of nests is either moderate or nil, in other words the variability of one caste is in some instances not appreciably correlated with the variability of any other caste in the nest. Owing to the fact that all the castes spring from the same parentage, we might have anticipated that a fairly high correlation would exist. We have therefore evidence that a similar environment can have a varying influence on the variabilities of the different castes.

A comparison of these results with those obtained from other social insects would be of much interest, and would throw additional light on the significance, or otherwise, of some of the observations made in this paper.

NOTE ON THE SKIN-COLOUR OF THE CROSSES BETWEEN NEGRO AND WHITE.

By KARL PEARSON, F.R.S.

THOSE who feel compelled at present to hold their final judgment with regard to Mendelism in suspense, who do not think the statistical proof of its generality by any means yet complete, and who still question on logical grounds many of the statements made with regard to it, have nevertheless been ready to emphasise the paramount service of Mendel in drawing attention to the great factor of segregation in many inheritance problems. This admission can be made without overlooking the facts—too often disregarded—that segregation is not a universal principle, that it is, where it does occur, often incomplete, and that even where it occurs and is more or less complete it does not necessarily follow the simple Mendelian ratios. The theory of the "pure gamete," the "unit character" and the "allelomorph" may have aided, suggested and controlled much experimental work on inheritance, but this theory has undoubtedly been pushed—chiefly by young and enthusiastic disciples of Mendelism, who thought that at last a formula of heredity requiring no mathematical knowledge had been discovered—far beyond the limits of actual experimental work, or in some cases beyond the inferences allowable from the data actually observed. The public has been dosed by the general Mendelian practitioner with:

$$(DR) \times (DR) = (DD) + 2(DR) + (RR)$$

and told that it solved all difficulties. But the higher consultants know that at the very best many complications arise, that even in segregation transitional forms occur occasionally or even frequently, and that "unit characters" are not independent but often highly correlated. They are also fully conscious that much straining of the theory of probability often is needed to make the ratios fit a simple Mendelian formula. The reason for these prefatory remarks lies in the fact that some time ago it was asserted by an ardent Mendelian that skin colour in crosses between dark and light skinned races would probably be found to obey Mendelian principles. It had been hitherto almost universally accepted that skin colour did not segregate, but that in a mixed population all tints according to the degree of mixture were to be found. This view of the matter appeared to be that of men who had long resided among mixed races, and had become axiomatic with the West Indies courts of justice when determining cases of doubtful paternity. The rule of a court of justice is generally one of practical experience in human affairs, but of course we cannot in science take it as conclusive evidence of the absence of segregation.

At first sight the question appears to be capable of an easy answer. If L represents a light skin and D a dark skin, we shall term the pure races (LL) and (DD), and the problem turns on whether segregation occurs when we have the mating:

$$(LD) \times (LD).$$

Is the result $(LL) + 2(LD) + (DD)$? Now without any hypothesis as to the nature of the skin of (LD), we ought when mulattos or Eurasians cross among themselves to find 25 p.c. of their offspring at least white skinned, and so readily distinguishable. The problem, however, is not so easily answerable, and for the following reasons:

(*a*) There is a considerable range of variability of pigmentation in the white races, and an equal range of variability in the dark races, which may also be said to have their "blonds" and "brunettes," although what the negroes term a 'fair' negro, would often be called by the European a black.

(*b*) Among the Eurasians in the populous parts of India an inquiry as to parentage is much resented. It is possible to examine the children in the Eurasian schools and often to observe their parents, but the fundamental question as to the parents' parents, the original (LL) and (DD), is generally unanswered.

(*c*) In the West Indies where the race differences are less acute, we are met by the difficulty that 60 p.c. of the children in some islands are born out of wedlock. Many mistakes in paternity are made, and colour as I have indicated is one of the definite factors in deciding this matter in a court of law.

Now I do not pretend to have settled the problem for either Eurasian or mulatto strains, but I have endeavoured to set on foot inquiries in the Eurasian schools in India and among medical men in the West Indies which may some day help to answer the problem. This note only proposes to consider some communications I have had with a correspondent in the West Indies. He is a medical man, who, except for his period of training in London, has spent his whole life in the West Indies and knows its people and their ways very intimately. He has most kindly provided me with a series of photographs illustrating some of the mixed types. It is very hard to indicate the various shades of colour unless all the subjects are taken on precisely the same plate, with the same exposure and the same illumination. I am having further observations made with von Luschan's skin mosaics, but I think the present photographs will suffice to indicate that there is a real gradation in the types.

The questions I put to my medical correspondent were as follows:

(1) Is white × negro a blend or not? Is it correct to say that the mulatto is a blend?

Answer. "To this question there is only *one* answer; it gives a definite well-recognised blend, and a blend which is easily seen and identified by any sensible man who has had any experience. You can infer and state freely, that there is this definite blend. But the colour of the mulatto varies, and practically may be divided into two sections:

(*a*) The brown mulatto, with a colour of light mahogany.

(*b*) The yellow mulatto with the colour of a well cleaned brown boot, which has not been much worn.

But I have never seen any reversion to the white or negro type in a genuine mulatto, and I have come in contact with hundreds of them. The yellow mulatto is comparatively uncommon here; roughly speaking I should say under 15 p.c. of all mulattos."

It will be seen from this result that a new problem is opened up—that of accounting for the difference between the brown and the yellow mulatto. The answer excludes the possibility of dominance in the Mendelian sense from the discussion.

My Figs. (i)—(iii) give pure negro individuals. Fig. (ii) is described as a perfectly black negress and Fig. (i) as a negro "as black as the ace of spades."* Fig. (v) is the photograph of a florid Englishman taken with the same camera as control. Fig. (iv) is a representative of the mulatto type.

The problem of the difference between the brown and yellow mulatto would be a remarkably interesting one to work out, but the difficulty of the inquiry might be great. Is it, perhaps, due to difference of pigmentation in the European parents? Or, to a difference in negroid race? One point, I think, deserves consideration with regard to further inquiry in this field: Does the sex of the white parent make any difference in the colour of the offspring? In searching through literature to find any reference to segregation in the offspring of mixed races, I have come across three cases only, in which the hybrid was directly stated not to be a blend or mulatto. The first case is due to Aristotle† who describes how a woman in Elis bore a *white* daughter to an Aethiopian, but this daughter had a black son by a white father. If the case were really authentic, it would be the rule proved by the exceptions, i.e. a Mendelian dominance of the white, followed by a Mendelian segregation, which nullifies this dominance of the white. The second case is cited by Parsons‡, who says that a white woman married a negro in York and had by him a perfectly negro child. Here we have dominance of the black. The third case is also due to Parsons; he tells how a white woman had a white child by a negro, but its buttock was black, i.e. it was a piebald. There may well be other cases, but I have not come across them. Now on these three cases no stress whatever can be laid, but they suffice to suggest that, whereas in the bulk of cases the male is a white and the female a black, it would be well to inquire whether a change of sex can produce any differences in the colour of the offspring or in the nature of the dominance.

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* In all photography of dark races, the high lights reflected from black surfaces must be allowed for.

† *De generatione Animalium* Lib. I. cap. XVIII.

‡ *Phil. Trans.* Vol. LV. 1765, p. 45.

If we accept that (LD) is a blend, we should expect that mulatto × white would give 50 p.c. of whites and 50 p.c. of blends. My next question was put to test this.

(2) Mulatto × white gives a quadroon. Is or is not the quadroon a blend? Theory says that the quadroon class should consist of half whites and half mulattos.

Answer. "With the small exception of the yellow mulattos the quadroon is almost invariably lighter in colour than the brown mulatto, and one is safe in saying that the quadroon is nearly always—say in 90 p.c. of cases—whiter than even the yellow mulatto. *Pure white skins do not occur in quadroons.* This statement is dogmatic and true."

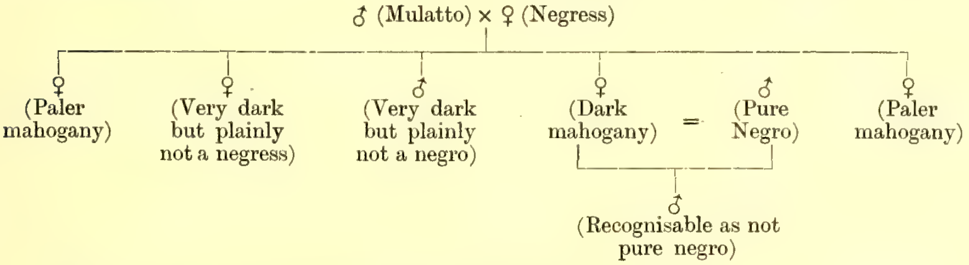
The next question I asked related to the cross $(LD) \times (DD)$.

(3) Mulatto × negro. Is this a blend rather darker than the mulatto or not? Theory would say that 50 p.c. of the offspring were mulattos and 50 p.c. negroes in skin colour.

Answer. "The mulatto × negro crosses produce what is here termed the 'Sambo,' a deep mahogany brown and they produce nothing else. They do not produce mulattos and they do not produce negroes. The Sambo type is very distinct, and there is, as far as my experience goes, no reversion either to the white or black races. I have never seen a single case of reversion to either mulatto or negro."

Fig. (vi) shows a Sambo girl of the rather lighter type. The colour is well shown in the hands (not in photograph) which are of a rich chocolate tint, and could not be mistaken for black. Figs. (vii) and (viii) give a Sambo girl darker than the average type, but no one with experience would mistake this girl for a negress.

The following pedigree is an example of the range found in a Sambo sibship:


♂ (Mulatto) × ♀ (Negress)
♀ (Paler mahogany)
♀ (Very dark but plainly not a negress)
♂ (Very dark but plainly not a negro)
♀ (Dark mahogany)
=
♂ (Pure Negro)
♀ (Paler mahogany)
♂ (Recognisable as not pure negro)

The colour range here is from something rather darker than the mulatto to something rather less dark than the negro. In this case the range of colour is fairly wide, and it is open to those whom it pleases to divide this or any other family into two halves, containing the lighter and darker members respectively. The difficulty of such a classification is that the dark mahogany members are quite distinct from negroes and the paler mahogany from mulattos.

Figs. (ix) and (x) give a dark chocolate coloured girl whose mother was the offspring of a mulatto and a slightly higher white strain (? quadroon) and father a negro. We see at once a softening of the Sambo tint.

It will be clear that the crosses $(LD) \times (LL)$ and $(LD) \times (LD)$ are more likely to give us definite answers to our problem than $(LD) \times (DD)$ owing to the considerable colour range in the Sambo. The next investigation therefore turns on $(LD) \times (LD)$ which should give us the segregation in its simplest form. I therefore asked the fourth question, but with some diffidence it must be confessed.

(4) Mulatto × mulatto. Does or does not this cross usually give a mulatto in colour? The theorists say that 25 p.c. should be pure white skins, 25 p.c. pure black skins and only 50 p.c. mulattos.

Answer. "This statement of those whom you call the theorists is the most ridiculously incorrect of the lot; indeed it would be very comic to make this statement in public before persons who knew. There are now and then slight variations from the usual mulatto brown or mulatto yellow, but you may be quite certain that no pure black skins nor pure white skins come from mulatto × mulatto. You can state this dogmatically."

I may add a few remarks more. Did Mendelism apply to the skin colour of the crosses between dark and light races, we should expect to find only three tints, the light, the dark and the hybrid, whatever the latter may be. The most distant "touch of the tar brush" would be visible, if visible at all, in the presence of the light mahogany of the mulatto. Yet the colour is just visible in the case of the offspring of a quadroon and a pure white I am familiar with, but is hardly discoverable in the case where one parent is a pure white and the other a cross between octoroon and quadroon. I think it probable that characters other than skin colour would offer better material for a possible "mendelising." The negroid lip, the crimped hair, the characteristic *alae nasi*, and the peculiar temper are qualities which can sometimes be traced after the disappearance of all colour. It is conceivable that they would fit the Mendelian theory closer than skin colour, and they serve better than colour to predict a distant negroid strain *.

Finally, I may say that I do not propose to ask my readers to take the views of my correspondent as conclusive, but they do, I think, deserve great weight. He has mixed all his life with all sorts and conditions of colours, and come into

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* Another correspondent with 32 years' experience in a West Indian Island confirms the opinions of my first correspondent, i.e. that blended colour is correct in the cases of mulatto, Sambo and quadroon. If a blackish child occurred in a family which should be mulatto, he would hold that the child was fathered by a black man. In fact he attributes to illicit connexion of mixed races any exceptions to the ordinary rule, and cites as evidence of West India experience the story of the man who said he was so dark in colour because a negro ran after his white mother when she was first married; the reply of the sceptic being: "I guess that nigger caught your mother." The same authority notes that if mulattos intermarry for some time the skin tends to get lighter in colour, but a full blooded negro also gradually inclines to become light in hue ("Pears' soap colour") if in a good position and subject to civilising influences. Lastly I may remark that he has noticed that the "bouquet d'Afrique" occurs sometimes in a pronounced form in one or two members of cross-blood families, even in Octoroons. Is this a true segregation?

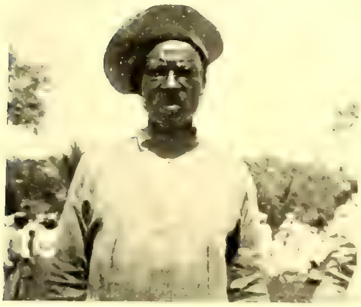


Fig. (i)

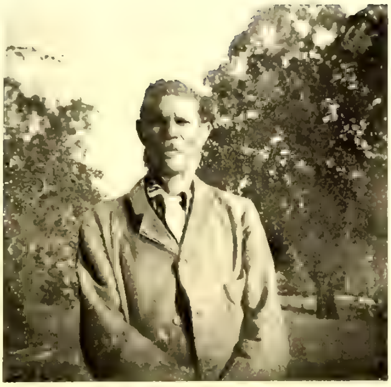


Fig. (iv)

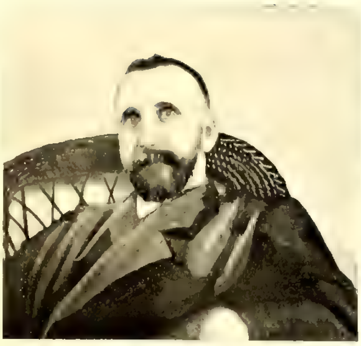


Fig. (v)

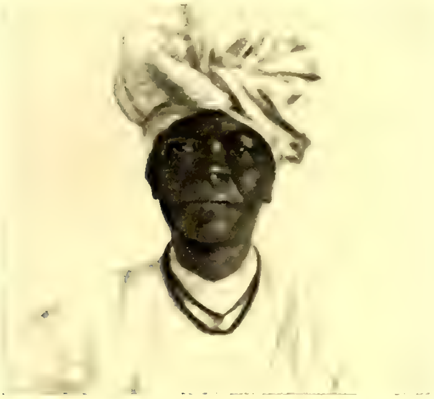


Fig. (ii)

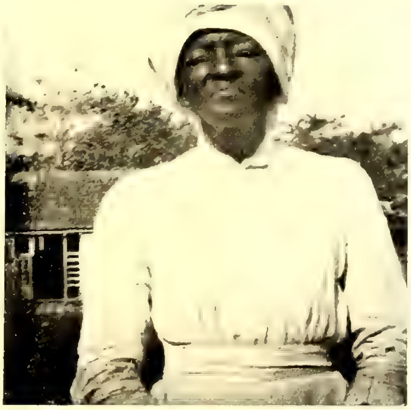


Fig. (iii)

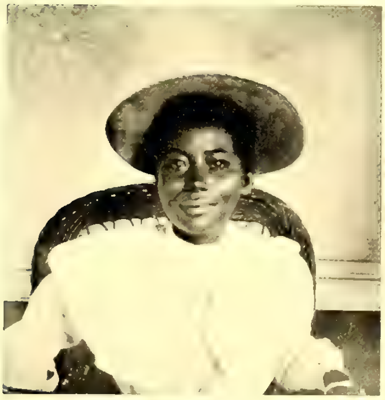


Fig. (vii)

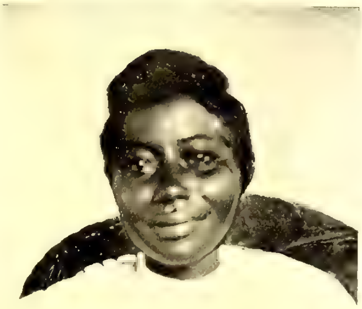


Fig. (viii)

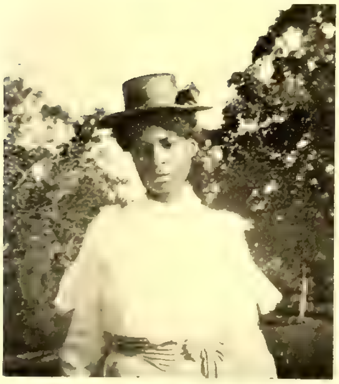


Fig. (vi)

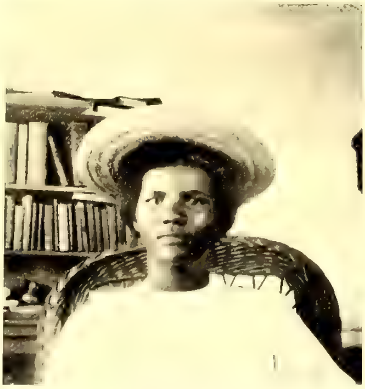


Fig. (ix)

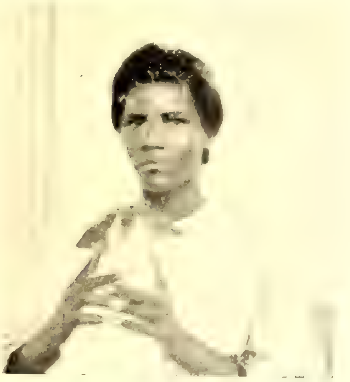


Fig. (x)

Figs. (i)—(iii) = pure negro. Fig. (iv) = negro × white. Fig. (v) = pure white. Figs. (vi), (vii), and (viii) = mulatto × negro. Figs. (ix) and (x) = mulatto-quadroon × negro.

I. *Picea excelsa Link.*

A. 15—20 Jahre alter Baum in einem Garten auf der Südseite meiner Wohnung.

Ich wollte zuerst feststellen, ob das Alter der Sprosse oder die Orientierung der Sprosse einen Einfluss auf die Variationskurve ausübe u. nahm deshalb vier getrennte Messungen vor: an der Ost- u. an der Nordseite des Baumes u. je Nadeln von letztjährigen u. von älteren Sprossen.

(1) 2700 *Nadeln von letztjährigen Sprossen von der Nordseite.* (Fig. 1.)

8	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*	*21*	*22*	*23*	*24*	mm.
5	12	20	76	159	263	**375**	340	343	**358**	286	202	132	79	33	14	3	(2700)
2	4	7	29	59	97	**139**	126	127	**133**	106	75	49	29	12	5	1	‰

(2) 2700 *Nadeln von älteren Sprossen von der Nordseite.* (Fig. 2.)

9	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*	*21*	*22*	*23*	*24*	*25*	mm.
14	45	91	197	270	**369**	355	350	**419**	303	138	64	38	27	12	7	1	(2700)
5	17	34	73	100	**137**	131	130	**155**	112	51	24	14	10	4	2	1	‰

(3) 2700 *Nadeln von letztjährigen Sprossen von der Ostseite.* (Fig. 3.)

10	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*	*21*	*22*	*23*	*24*	*25*	*26*	*27*	*28*	mm.
4	21	62	141	261	302	354	**442**	370	237	175	135	64	36	33	20	19	15	9	(2700)
1	8	23	52	97	112	131	**164**	137	88	65	50	24	13	12	8	7	6	3	‰

(4) 2700 *Nadeln von älteren Sprossen von der Ostseite.* (Fig. 4.)

9	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*	*21*	*22*	*23*	*24*	*25*	*26*	*27*	mm.
6	48	103	233	366	**401**	326	282	**354**	290	125	74	32	15	19	15	7	3	1	(2700)
2	18	38	86	136	**148**	121	104	**131**	107	46	27	12	6	7	6	3	1	1	‰

Übersicht

	Variationsweite	Gipfel
(1)	8—24 mm.	14 u. 17 mm.
(2)	9—25 mm.	14 u. 17 mm.
(3)	10—28 mm.	14 (angedeutet) u. 17 mm.
(4)	9—27 mm.	14 u. 17 mm.

Diese Ergebnisse zeigen, dass an unserm Baume weder die Stellung der Nadeln an Zweigen verschiedenen Alters, noch die Orientierung der Zweige einen wesentlichen Einfluss auf die Variationskurve hatten.

B. Gleich alter Baum wie A, nur wenige Meter von ihm entfernt stehend. Ich wollte an diesem Baume eine Kontrolle darüber ausüben, ob das Alter der Zweige tatsächlich keinen Einfluss auf den Verlauf der Variationskurve habe. Ich mass deshalb je 1350 Nadeln von letztjährigen u. von älteren Sprossen von der Nordseite des Baumes.

(1) 1350 *Nadeln letztjähriger Sprosse.* (Fig. 5.)

8	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*	*21*	*22*	*23*	*24*	mm.
2	9	22	35	110	157	**189**	150	147	**200**	139	72	52	36	24	5	1	(1350)
1	7	16	26	81	116	**140**	111	109	**148**	103	53	39	27	18	4	1	‰

(2) 1350 *Nadeln älterer Sprosse.* (Fig. 6.)

8	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*	*21*	*22*	*23*	mm.
1	2	12	37	119	156	**176**	171	177	**198**	150	92	38	15	5	1	(1350)
1	2	9	27	88	115	**130**	127	131	**147**	111	68	28	11	4	1	‰

Sowohl Variationsweite als auch die Lage der Gipfel stimmen miteinander überein, aber auch mit den Resultaten von A.

C. Gleich alter Baum wie A u. B, in unmittelbarer Nähe derselben. Die Nadeln wurden ohne Wahl von alten u. jungen Zweigen gepflückt (Fig. 7).

9	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*	*21*	*22*	*23*	*24*	*25*	*26*	mm.
8	67	220	406	699	**904**	842	700	562	445	299	197	124	84	57	40	12	2	(5668)
1	12	39	72	123	**160**	148	123	99	78	53	35	22	15	10	7	2	1	‰

Die Variationsweite erstreckt sich von 9—26 mm., also ungefähr wie bei den vorhergehenden Kurven, hingegen ist diese Kurve unsymmetrisch *eingipfelig,* mit Gipfel bei 14 mm.

D. Nadeln aus dem Gipfel eines etwa 40 Jahre alten Baumes aus dem Walde von Peter u. Paul (Fig. 8).

9	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	mm.
7	28	88	214	403	**666**	579	462	276	76	4	(2803)
3	10	31	76	144	**238**	207	165	99	27	1	‰

Variationsweite von 9—19 mm., Gipfel bei 14 mm.

E. Hier wurden von unserm Christbaum die Endsprosse des zweitobersten Quirls abgeschnitten u. die Nadeln von zweien derselben gemessen (Fig. 9).

10	*11*	*12*	*13*	*14*	*15*	*16*	*17*	mm.
3	41	118	168	**225**	173	49	2	(779)
4	53	151	215	**289**	222	63	3	‰

Variationsweite 10—17 mm., Gipfel bei 14 mm. Muster eines eingipfeligen, symmetrischen Variationspolygons.

F. Ein 80—100jähriger alleinstehender Baum nördlich vom Institut Dr. Schmidt. Einer meiner Schüler, A. Jobin, mass von den ihm erreichbaren Ästen 4015 Nadeln (Fig. 10).

2	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*	*21*	*22*	*23*	*24*	mm.
3	6	26	50	66	**88**	79	91	89	157	302	404	**426**	418	376	310	**324**	306	210	126	76	62	20	(4015)
1	2	6	12	16	**22**	20	23	22	39	76	101	**106**	104	94	77	**81**	76	52	31	19	15	5	‰

Die Variationsweite erstreckt sich von 2 bis 24 mm. Die Gipfel liegen bei **7**, 14 u. 18 mm. Diese Messungen wurden im Frühling ausgeführt, die übrigen im Winter, wodurch vielleicht die tiefe untere Variationsgrenze erklärt ist. Neu sind die Gipfel bei 7 u. bei 18 mm.

II. *Abies alba Mill.*

A. Ein circa 20jähriger Baum aus dem Stadtpark in St. Gallen (Fig. 11).

4	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*
1	1	6	27	59	104	141	208	293	362	**377**	322	266
1	1	2	7	17	30	40	59	83	103	**108**	92	76

17	*18*	*19*	*20*	*21*	*22*	*23*	*24*	*25*	*26*	*27*	*28*	mm.
268	240	214	202	137	86	72	46	34	17	14	3	(3500)
77	68	61	57	39	25	21	13	10	5	4	1	°/oo

Die Länge variiert also zwischen 4 u. 28 mm. u. die Gipfel liegen bei 14 u. 17 mm.

B. Ein circa 70—80jähriger Baum aus dem Sitterwald. Nadeln von den vom Boden erreichbaren Ästen (Fig. 12).

7	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*
4	18	26	55	68	87	123	**126**	113	103	90	75	68	56
3	13	19	39	49	62	88	**90**	81	73	65	54	48	40

21	*22*	*23*	*24*	*25*	*26*	*27*	*28*	*29*	*30*	*31*	*32*	*33*	*34*	mm.
60	**67**	47	34	**41**	35	31	28	25	8	5	3	3	1	(1400)
43	**48**	33	24	**29**	25	22	20	18	6	4	2	2	1	°/oo

Variationsweite von 7 bis 34 mm. Gipfel bei 14, 22 u. 25 mm.

C. Ein 60—70jähriger Baum aus dem Sitterwald. Nadeln der vom Boden erreichbaren Äste (Fig. 13).

7	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*	*21*
2	2	9	20	30	61	75	123	207	244	**355**	332	250	224	253
1	1	2	4	7	13	17	27	46	52	**79**	74	56	50	56

22	*23*	*24*	*25*	*26*	*27*	*28*	*29*	*30*	*31*	*32*	*33*	*34*	*35*	mm.
281	290	**310**	283	253	245	217	155	125	94	48	18	3	2	(4511)
62	64	**69**	63	56	54	48	34	28	21	11	4	1	1	°/oo

Die Länge der Nadeln variiert zwischen 7 u. 35 mm. Die Gipfel liegen bei 17 u. 24 mm.

D. Ein ca. 15jähriger Baum am Waldrand zwischen Kronbühl u. Steinach (Fig. 14).

7	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*
1	2	4	8	25	55	115	171	227	244	**309**	286	258
1	1	1	2	7	16	33	49	65	70	**88**	82	74

20	*21*	*22*	*23*	*24*	*25*	*26*	*27*	*28*	*29*	mm.
268	**324**	297	262	233	162	126	71	47	5	(3500)
77	**93**	85	75	67	46	36	20	13	1	°/oo

Die Länge variiert zwischen 7 u. 29 mm. u. die Gipfel liegen bei 17 u. 21 mm.

III. *Larix decidua Mill.*

A. Etwa 15 Jahre alter Baum im Sitterwald. Es wurden nur die Nadeln der Kurztriebe gemessen (Juli 1908). (Fig. 15.)

6	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*
3	14	29	35	59	78	98	121	132	158	189	**237**	202
1	5	10	12	20	26	33	40	44	53	63	**79**	67

19	*20*	*21*	*22*	*23*	*24*	*25*	*26*	*27*	*28*	*29*	mm.
212	227	**247**	210	186	164	153	130	67	47	2	(3000)
71	76	**82**	70	61	55	51	43	22	16	1	‰

Variationsweite von 6 bis 29 mm. Gipfel bei 17 u. 21 mm.

B. Etwa 30 Jahre alter Baum im Sitterwald. Nur Nadeln von Kurztrieben (Juli u. Aug. 1908), (Fig. 16).

8	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*	*21*	*22*	*23*	*24*	*25*
2	6	5	7	30	54	62	84	100	**149**	124	103	105	134	138	142	142	168
1	1	1	2	7	12	14	19	22	**33**	28	23	23	30	31	32	32	37

26	*27*	*28*	*29*	*30*	*31*	*32*	*33*	*34*	*35*	*36*	*37*	*38*	*39*	*40*	mm.
208	253	**327**	310	343	**356**	327	270	192	159	94	69	31	5	1	(4500)
46	56	**73**	69	76	**79**	73	60	43	35	21	15	7	1	1	‰

Die Länge variiert zwischen 8 u. 40 mm. Die Gipfel liegen bei 17, 28, 31 mm.

B*. Es wurden nun noch 500 Nadeln von Langtrieben dieses Baumes gemessen (Fig. 17).

7	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*
1	5	4	5	8	28	41	**58**	39	51	57	**75**	45
2	9	8	9	15	53	78	**110**	74	97	108	**143**	86

20	*21*	*22*	*23*	*24*	*25*	*26*	*27*	*28*	*29*	*30*	*31*	mm.
29	19	11	12	9	11	5	3	2	3	1	4	(526)
55	36	21	23	17	21	9	6	4	6	2	8	‰

Hier variiert die Länge zwischen 7 u. 31 mm., die Hauptgipfel liegen bei 14 u. 18 mm.

IV. *Pinus montana Mill, var. pumilio.*

Von einem in einer Anlage der Stadt St. Gallen stehenden Exemplar wurden 19000 Nadeln gemessen u. zwar von je zwei beisammen stehenden nur eine, weil die beiden meistens gleich lang sind. Weil mir an der Lage des hier auftretenden Gipfels sehr viel liegt, so gebe ich zwei Zahlenreihen: die erste zeigt die Ergebnisse nach 8000 Messungen, die zweite nach 19000 Messungen, u. zwar blieb von 8000

contact with them every day in a large but poor practice. He has, I feel sure, no bias to any theory of heredity, and I think my questions first put the modern theory before him. The main point is that the segregation in the second generation to pure white or black skins does not occur. One quotation more from his letters, which had reference to the question of whether the lighter shades of the mixed race might have a dark skin as a latent quality.

> "Now I think the question you wanted an answer to is this: When the mixed breed approaches the European side, are there reversions to a definitely negroid type? You reserved your opinion when I saw you in the summer, until I had formulated my experience. That experience is that such reversions are comparatively rare, sufficiently rare to be practically disregarded in a court of law in the decision of bastardy paternity cases. I cannot give you definite statistics, the subject, as you may well imagine in a mixed race community like this, bristles with delicate social difficulties. After many years of medical practice here among all classes and colours I feel sure that I am justified in saying that the reversions to the negroid type are *distinctly* uncommon. Of course in families of the mixed breed you will often see a difference in *colour* pure and simple; this is not at all uncommon, and I would make a marked distinction between this phenomenon and the phenomenon of a throwback to the negro. You will not infrequently see the same thing in European families, and if you are going to consider it in the case of Englishman × Negro, you must also consider how it would apply in the case of Englishmen × Englishwomen."

I take it that my correspondent is here referring to the continuous variability within the family—demonstrably inheritable,—which some disciples of Mendel term "fluctuating" variability and believe to have no importance for the theory of heredity.

> "'Sports' or 'throwbacks' do occur, but are really rare; the milder form, i.e. the form which is *barely* evident in tint is not uncommon, but only a practised or accurately observing eye would detect it. 'Sports' to the pure white or the pure negro are practically unknown; in all my life I have not heard of a single one."

In view of the opinions I have cited above, I think, the suggestion that skin colour 'mendelises' should not be vaguely made until some very definite evidence in its favour is forthcoming. I should welcome any views on the above four questions from those having life-long experience of mixed races, or having from mission or medical work special opportunities of studying the offspring of mixed races. Actual data as to skin tints taken on Broca's or von Luschan's scales would be very valuable, and any photographs of individuals of mixed race, taken when possible alongside individuals of the two pure races, will receive a ready publication in this journal.

ÜBER DIE LÄNGENVARIATION DER CONIFERENNADELN.

Von A. HEYER (St. Gallen).

Im 1. Heft des 1. Jahrganges dieser Zeitschrift (Okt. 1901) veröffentlichte mein Freund Herr Prof. Dr. Ludwig in Greiz in seiner Arbeit *Variationsstatistische Probleme u. Materialien* u. a. auch meine Messungen der Nadeln einer Kiefer (*Pinus silvestris*). Auf pag. 22 l. c. zitiert er eine briefliche Mitteilung, in welcher ich ihm von einer "Einheitslänge" gesprochen hatte, deren Multipla die Kurvengipfel zu bestimmen scheinen. Als diese Einheitslänge drängte sich mir schon bei den ersten Tausendmessungen die Länge von 7 mm. auf. Ich liess dann die Sache Jahre lang liegen u. beschäftigte mich mit den Correlationsverhältnissen zwischen Länge u. Breite der Laubblätter von Prunus spinosa (Referat in den Verhandlungen der Schweiz. Naturforschenden Gesellschaft 1906 in St. Gallen), wobei in der Längenvariation der Blattspreite merkwürdigerweise auch die Gipfelzahlen 24 u. 28 mm. zum Ausdruck kamen, die ich bei *Pinus silvestris* gefunden hatte. Besonders diese Tatsachen bestimmten mich, wieder zu den Coniferen zurückzukehren, um auch an anderen Arten die Längenvariation der Nadeln zu studieren.

Ich stellte mir die Aufgabe, die Untersuchung über alle in der Schweiz wild wachsenden Coniferen auszudehnen. Das ist nun in den letzten 1½ Jahren geschehen. Wenn es auch erwünscht wäre, besonders von den langnadeligen Arten noch andere Individuen herbeizuziehen, so scheinen mir doch die bisher gewonnenen Resultate einer vorläufigen Publikation wert zu sein. Ich hoffe dadurch auch andere Forscher anzuregen, sich auf diesem etwas verlassenen Felde zu betätigen, wo die Arbeit zwar mühsam u. zeitraubend ist, wo aber sicher wertvolle Resultate zu gewinnen sind.

Gemessen wurde stets frisches Material u. zwar mit einem gewöhnlichen in Millimeter eingeteilten Massstab. Die Längen wurden in ganzen Millimetern niedergeschrieben u. die Resultate in der Regel nach 1000 Messungen geordnet.

Um einen bequemeren Vergleich zu ermöglichen, habe ich bei den kurznadeligen Arten, wo zugleich mehrere Individuen zur Untersuchung gelangten, die Frequenzen auf ‰ reduziert u. die graphische Darstellung nach dieser Reduktion vorgenommen.

bis 19000 bei Controlle von 1000 zu 1000 der Gipfel unverändert auf 49 mm. (Fig. 18).

14	*15*	*16*	*17*	*18*	*19*	*20*	*21*	*22*	*23*	*24*	*25*	*26*	*27*	*28*	*29*	*30*	*31*	*32*	*33*
2	1	5	2	4	5	9	14	15	18	26	30	29	45	42	56	78	68	82	113
3	2	7	4	7	12	20	20	22	30	47	59	61	85	97	109	125	135	161	198

34	*35*	*36*	*37*	*38*	*39*	*40*	*41*	*42*	*43*	*44*	*45*	*46*	*47*	*48*	*49*	*50*
120	144	168	170	203	223	210	207	266	287	335	419	424	436	429	**453**	428
225	276	326	381	415	428	440	461	542	561	689	790	803	844	847	**871**	796

51	*52*	*53*	*54*	*55*	*56*	*57*	*58*	*59*	*60*	*61*	*62*	*63*	*64*	*65*	*66*
319	293	296	226	211	149	150	146	124	105	63	59	45	54	39	28
736	730	695	634	600	541	493	472	442	372	316	305	268	246	216	176

67	*68*	*69*	*70*	*71*	*72*	*73*	*74*	*75*	*76*	*77*	*78*	*79*	*80*	*81*	mm.
38	27	18	13	8	8	3	6	4	1	1	—	—	—	—	(8000)
185	146	111	97	72	49	52	40	40	31	15	11	7	2	1	(19000)

Die Variationsweite war also nach 8000 Messungen von 14 bis 77 mm.; durch Hinzukommen längerer Nadeln verschob sie sich nach oben um 4 mm. bis 81 mm. Der Gipfel 49 aber blieb unverändert.

V. *Pinus Cembra L.*

A. Ein etwa 15jähriger Baum in einem Garten am Rosenberg, St Gallen (Fig. 19).

Es wurde von den 5 an einem Kurztriebe stehenden Nadeln je nur eine gemessen, da die 5 meist gleich lang sind.

10	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*	*21*	*22*	*23*	*24*	*25*
1	—	3	3	3	3	1	5	3	9	8	5	6	5	9	12

26	*27*	*28*	*29*	*30*	*31*	*32*	*33*	*34*	*35*	*36*	*37*	*38*	*39*	*40*	*41*
13	16	18	21	23	18	18	21	31	36	35	40	32	49	55	38

42	*43*	*44*	*45*	*46*	*47*	*48*	*49*	*50*	*51*	*52*	*53*	*54*	*55*	*56*	*57*
44	67	57	81	83	76	76	**102**	86	84	94	83	90	98	96	**114**

58	*59*	*60*	*61*	*62*	*63*	*64*	*65*	*66*	*67*	*68*	*69*	*70*	*71*	*72*	*73*
111	98	93	90	107	**122**	94	97	92	108	108	113	**125**	83	86	78

74	*75*	*76*	*77*	*78*	*79*	*80*	*81*	*82*	*83*	*84*	*85*	*86*	*87*	*88*	*89*
84	73	46	**56**	52	41	32	24	23	**28**	21	9	10	10	5	5

90	*91*	*92*	*93*	*94*	*95*	*96*	*97*	mm.
4	—	—	—	—	—	—	1	(4000)

Die Variationsweite erstreckt sich hier von 10 mm. bis 90, resp. 97 mm. Die Zahl der Messungen ist noch viel zu klein, um bei einer so grossen Variationsweite festsitzende Gipfel zu liefern. Immerhin erscheinen die Anhäufungen bei 49, 57, 63, 70, 77 u. 83 mm. bemerkenswert.

B. Ein Baum aus der Umgebung von Pontresina (Engadin). Über das Alter desselben habe ich keine Anhaltspunkte (Fig. 20).

20	*21*	*22*	*23*	*24*	*25*	*26*	*27*	*28*	*29*	*30*	*31*	*32*	*33*	*34*
1	3	4	6	5	6	9	4	15	10	16	22	18	19	19

35	*36*	*37*	*38*	*39*	*40*	*41*	*42*	*43*	*44*	*45*	*46*	*47*	*48*	*49*
31	27	43	41	58	70	80	71	98	109	124	138	178	194	209

50	*51*	*52*	*53*	*54*	*55*	*56*	*57*	*58*	*59*	*60*	*61*	*62*	*63*	*64*
234	250	289	304	300	320	**365**	349	362	**368**	348	302	300	283	261

65	*66*	*67*	*68*	*69*	*70*	*71*	*72*	*73*	*74*	*75*	*76*	*77*	*78*	*79*
259	206	216	200	148	124	101	84	79	56	46	43	25	39	26

80	*81*	*82*	*83*	*84*	*85*	*86*	*87*	*88*	*89*	*90*	*91*	*92*	mm.
31	15	14	4	8	7	3	2	—	—	—	—	1	(8000)

Die graphische Darstellung zeigt, dass die Zahl der Messungen an diesem Baume noch um einige Tausend vermehrt werden müsste, um ein einwandfreies Polygon zu liefern. Leider war es mir einfach unmöglich, das dazu notwendige Material zu bekommen. Die Variationsweite erstreckt sich von 20 bis 87 resp. 92 mm. u. die Gipfel liegen bei 56 u. 59 mm. Beim Vergleich der Variationspolygone der beiden Bäume A u. B, als von letzterem 4000 Nadeln also ebenso viel wie von A gemessen waren, fiel mir auf, wie der Engadiner Baum ein viel einheitlicheres Polygon mit einem einzigen deutlichen Hauptgipfel (bei 59) aufwies als der in St. Gallen gewachsene Baum A. Ich vermutete, dass hier das Klima von Einfluss sein könnte, weil das Engadin zwar einen kurzen Sommer, aber mit fast stets schönem Wetter aufweist, so dass das Wachstum ungestört vor sich gehen kann, während St. Gallen mit vielen trüben u. Regentagen ausgezeichnet ist, an denen die Temperatur rasch fällt u. so das Wachstum hemmen muss. Es wäre eine Frage für sich, durch weitere Messungen diesen Beziehungen nachzugehen.

VI. *Taxus baccata L.*

A. Ziemlich alter Baum im Sitterwald bei St. Gallen. Da derselbe einen üppigen Stockausschlag besitzt, so mass ich die Nadeln dieses Ausschlags (7000) u. die der Krone 5000 besonders.

(1) *Nadeln des Stockausschlags.* (Fig. 21.)

9	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*	*21*	*22*
1	19	32	72	107	**147**	140	163	**250**	227	217	230	274	291

23	*24*	*25*	*26*	*27*	*28*	*29*	*30*	*31*	*32*	*33*	*34*	*35*	*36*
313	**327**	298	299	327	**404**	332	317	288	**295**	264	228	182	165

37	*38*	*39*	*40*	*41*	*42*	*43*	*44*	*45*	*46*	*47*	*48*	*49*	mm.
175	148	107	101	76	**77**	43	26	19	7	7	4	1	(7000)

(2) *Nadeln aus der Krone.* (Fig. 22.)

10	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*	*21*	*22*	*23*	*24*	*25*	*26*	*27*	*28*	*29*	*30*	*31*	*32*	*33*	*34*	*35*	*36*	*37*	*38*	*39*	*40*	*41*	*42*	*43*	*44*	*45*	mm.
7	24	39	52	79	**80**	74	**110**	99	105	112	133	156	179	**207**	193	208	242	**296**	278	248	263	**294**	274	258	251	208	205	132	79	48	28	22	12	4	1	(5000)

Bei (1) variiert die Länge zwischen 9 u. 49 mm. u. die Gipfel liegen bei 14, 17, 24, 28, 32, 37, 42 mm. Bei (2) erstreckt sich die Variationsweite von 10 bis 45 mm. u. die Gipfel liegen bei 15, 17, 24, 28, 32 mm.

B. Baum neben meiner Wohnung, angebaut.

6	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*	*21*	*22*	*23*	*24*	*25*	*26*	*27*	*28*	*29*	*30*	*31*	*32*	*33*	*34*	*35*	mm.
3	17	44	77	121	199	311	402	473	565	668	1024	**1054**	995	881	769	708	499	373	234	181	125	99	65	49	26	20	11	4	3	(10000)

Die Kurve ist eingipfelig, Gipfel bei 18 mm., während die Variationsweite zwischen 6 u. 35 mm. liegt.

VII. *Juniperus communis L.*

Ein Strauch von der Hinterkreuzalp bei Trogen (St. Appenzell).

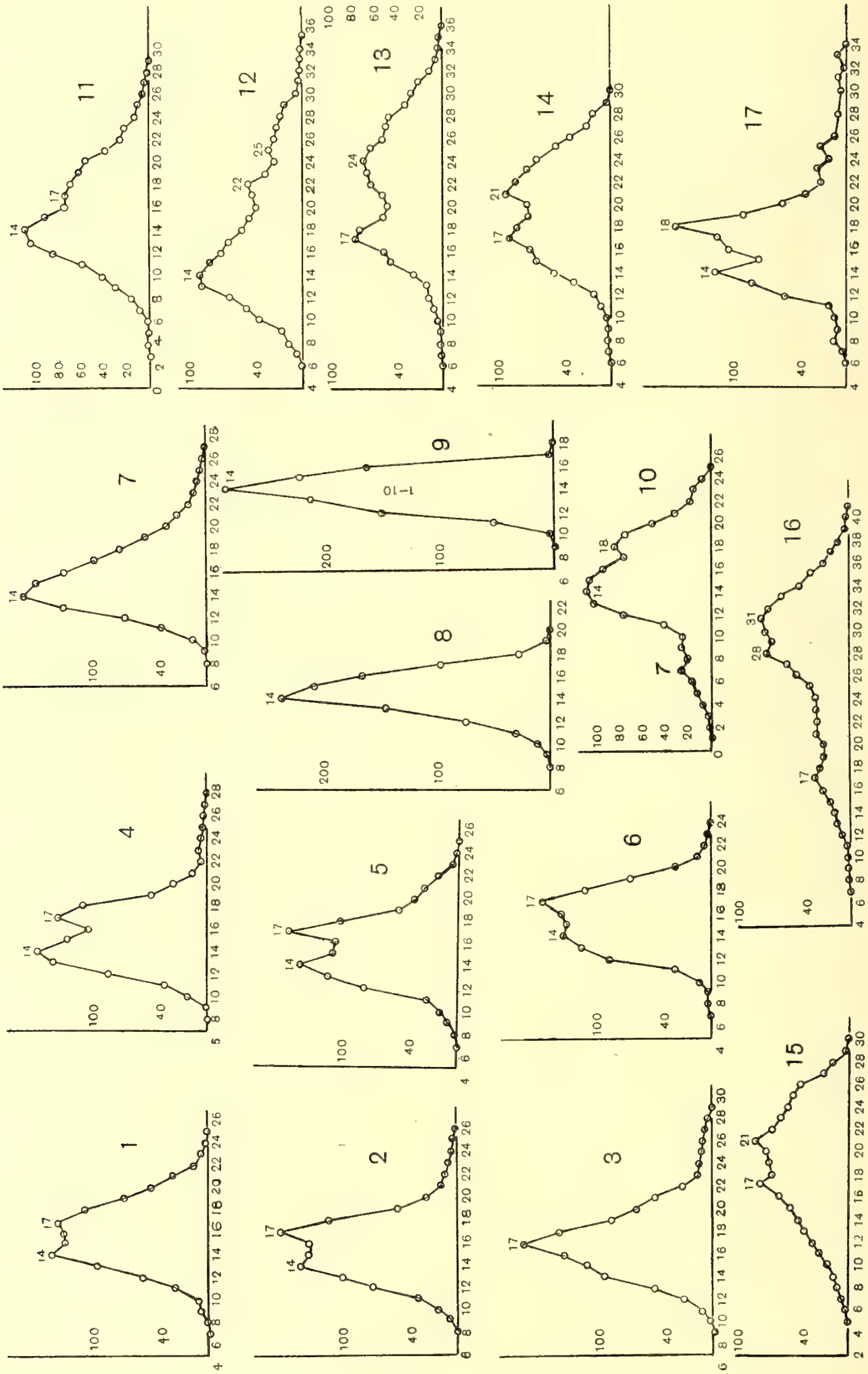
3	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*	*21*	*22*	mm.
11	39	73	93	130	**160**	151	165	179	207	224	**254**	238	204	151	95	63	33	20	10	(2500)

Variationsweite von 3 bis 22 mm., Hauptgipfel bei 14 mm., Nebengipfel bei 8 mm. (Fig 24).

VIII. *Pinus silvestris L.*

Der Vollständigkeit wegen wiederhole ich auch noch die Zahlen von *Pinus silvestris*, die in der eingangserwähnten Arbeit von Ludwig schon publiziert sind.

7	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*	*21*	*22*	*23*	*24*	*25*	*26*	*27*	*28*	*29*	*30*	*31*	*32*	*33*	*34*	*35*	*36*	*37*	*38*	*39*	*40*	*41*	*42*	*43*	*44*	*45*	*46*	*47*	*48*	*49*	mm.
8	15	32	27	47	55	114	136	183	233	317	386	463	530	603	701	773	922	820	807	832	921	727	602	469	390	263	189	140	102	69	52	27	18	8	4	5	1	2	3	—	2	2	(12000)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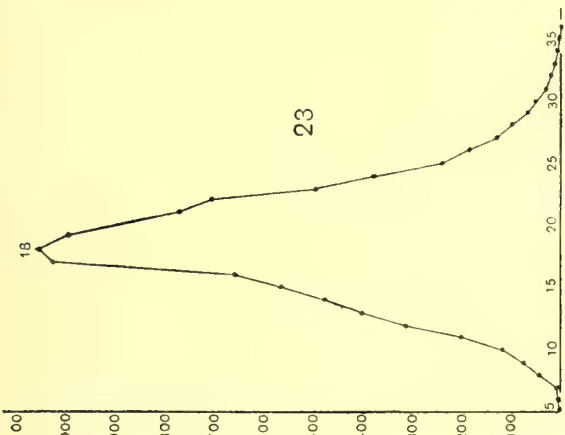
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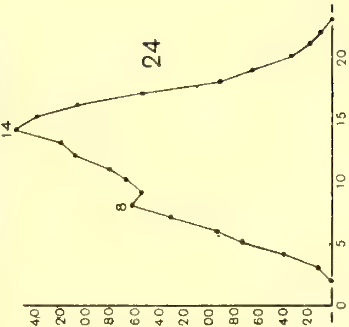
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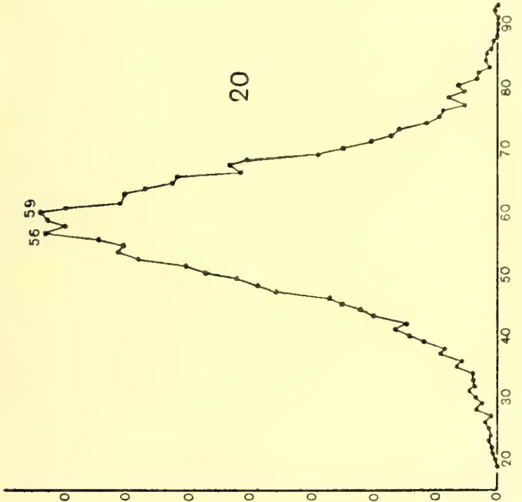
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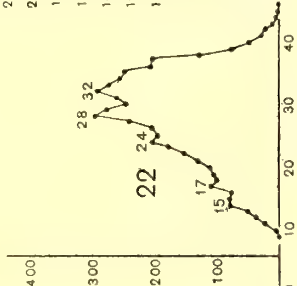
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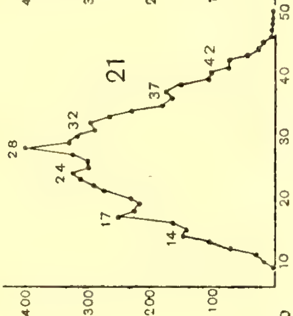
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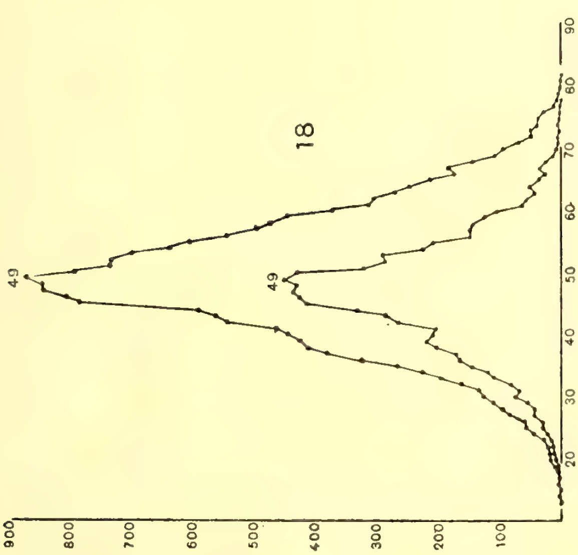
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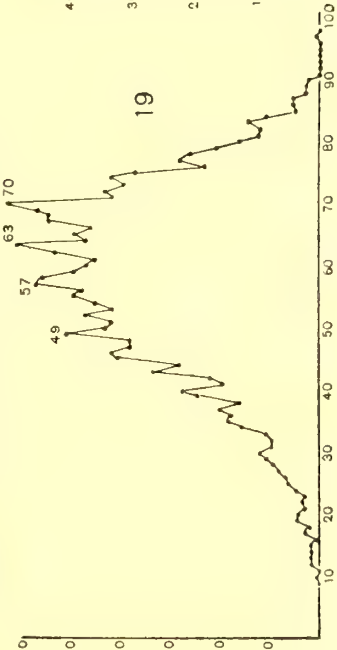
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Die Variationsweite liegt zwischen 7 u. 49 mm. u. die Gipfel liegen bei 24 u. 28 mm.

Vergleicht man nun die Gipfel bei den verschiedenen Arten, so fällt vor allem auf, dass die gleichen Gipfelzahlen wiederkehren, ohne Rücksicht auf die Art. Es sind das die Gipfel 14 u. 17 bei den kurznadeligen, dann 24, 28, 32 bei den Pflanzen mit mittellangen Nadeln. Auch 49 kommt zweimal vor. Stellt man von allen untersuchten Pflanzen die Gipfelzahlen zusammen (wobei ich für die Bäume mit mehreren Zahlenreihen stets nur *eine* berücksichtige), so ergibt sich, dass von den 52 deutlich ausgesprochenen Gipfeln 26 auf Multipla der Länge 7 mm. fallen [**1**·(7)+**11**·(14)+**3**·(21)+**4**·(28)+**1**·(42)+**2**·(49)+**1**·(56)+**1**·(63)+**1**·(70)+**1**·(77)], 21 fallen in die Mitte zwischen solche Zahlen hinein u. 5 fallen anderwärts. (Zählt man jede vorkommende Gipfelzahl nur einmal, so erhält man 21 Gipfelzahlen u. davon sind 10 Multipla von 7.) Solche Mittelzahlen wären zwar genau 10,5; 17,5; 24,5; 31,5 etc. mm. Da aber mit der Millimeter-Einheit gemessen wurde, betrachte ich die auf die benachbarten Ganzen fallenden Gipfel als eigentlich in die Mitte gehörend, zumal ausser 17 tatsächlich auch 2 Mal der Gipfel 18 auftritt, ausser 24 auch der Gipfel 25, ausser 32 auch der Gipfel 31. Bei der schön gebauten Kurve Fig. 23 tritt deutlich die Tendenz hervor, den Gipfel zwischen 17 u. 18 zu fixieren.

Es scheint demnach, dass in der Tat eine "Einheitslänge," wie ich sie schon früher vermutet hatte, bei der Fixierung der Gipfel eine Rolle spiele. Vielleicht ist diese "Einheitslänge" 7 mm. u. die zwischen den Multiplen gelegenen Gipfel sind Summationsgipfel, entstanden durch die Combination zweier Kurven mit Gipfeln bei den benachbarten Multiplen von 7 mm. Oder aber die "Einheitslänge" ist 3,5 mm. u. die Multiplen davon wären 7; 10,5; 14; 17,5; 21; 24,5; 28; 31,5 etc. Es sei noch besonders darauf hingewiesen, dass die Variation oft in der Nähe von 7 mm. beginnt u. in der Nähe der oben hervorgehobenen Zahlen aufhört, ohne dass ich einen sehr grossen Wert auf die wirklichen Anfangs- u. Endpunkte der Kurve legen möchte, da ja der Zufall eine sehr grosse Rolle spielt, indem er uns einige wenige Nadeln, welche diese Endpunkte bestimmen, in die Hände spielt oder aber vorenthält.

Es ist nun auffallend, dass die von mir bei den Coniferen gefundenen Gipfelzahlen auch bei Laubhölzern vorkommen. Ich selbst hatte einige derselben bereits bei den Blättern von *Prunus spinosa* ermittelt. In einer interessanten Arbeit *Beiträge zur Physiologie des Flächenwachstums der Pflanzen* von G. Ritter (*Bot. Centralblatt,* Bd. XXII. Abt. II. 1907) wird versucht, diese Gipfellagen zu interpretieren. Es handelt sich dabei um die Längenvariation der Laubblätter von *Vaccinium Vitis Idaea, V. Myrtillus* u. *Myrtus communis* u. es werden die Gipfel bei 10, 14, 17, 20, 22, 24, 26, 28, 32, 36 mm. gefunden. Diese Zahlen verhalten sich wie die Quadratwurzeln aus den Fibonaccizahlen der Haupt- u. Nebenreihe. Wenn nun das Längenwachstum pflanzlicher Organe schubweise nach der Fibonaccireihe erfolgt, so ist es sehr plausibel, dass beim Flächenwachstum der Zuwachs in einer Dimension schubweise nach den Quadratwurzeln aus diesen Zahlen vor sich geht. Nun fragt es sich: handelt es sich bei den Coniferennadeln auch um Flächenwachstum in dem Sinne wie bei den Laubblättern der oben genannten Pflanzen? Doch wohl kaum. Hier sollte man annehmen dürfen, geeignetes Material für das Studium des Längenwachstums vor sich zu haben. In diesem Falle liesse sich schwer erklären, wie die Gipfel trotzdem kollidieren.

Ausserdem bin ich nicht überzeugt, dass die Gipfel bei 20 u. 22 mm. in den Ritter'schen Reihen echte Gipfel sind. Zwei Gipfel, die nur durch eine einzige Klasse getrennt sind, kommen mir immer verdächtig vor, besonders wenn sie geraden Zahlen angehören, weil—ich habe einige Erfahrung darin—diese Zahlen stets unwillkürlich bevorzugt werden auf Kosten der ungeraden. Es wäre sehr gut möglich, dass 21 der wahre Gipfel wäre, u. dann würde er in meine Zahlenreihe passen (siehe übrigens Ritter l. c. Fig. 3).

Vorläufig, nachdem verhältnismässig noch wenig Material vorliegt, kann die Theorie jedenfalls keine endgültigen Sätze aufstellen. Die nächste Aufgabe auf diesem Gebiete wird sein, durch grosse Zahlen die Gipfel definitiv festzustellen, ganz besonders aber diejenigen der höhern Klassen, durch Untersuchung von Material von recht ausgedehnter Variationsweite.

STATISTICAL STUDY OF ANTI-TYPHOID INOCULATION.

By G. D. MAYNARD, F.R.C.S.E., Pretoria.

In a paper read before the South African Medical Congress of 1908, Major Buist, R.A.M.C., has collected a considerable number of figures relating to anti-typhoid inoculation. The conclusion that he considers these figures lead to is that inoculation is of decided benefit, both in preventing attack and in lowering the case mortality. It seemed that in view of the sparseness of the statistics at present available, it was more than ever desirable to examine such as we have by modern statistical methods. To base deductions on percentages, apart from their probable errors, is likely to lead to wrong conclusions; and it is only by the help of methods such as those here employed that we can hope to learn all that the data signify.

The statistics used in this paper have been obtained from the above-mentioned source, with the exception of the table containing the Transvaal figures, which were kindly supplied to me by Major Buist at a later date.

The coefficients of correlation—between inoculated and freedom from attack, and between attacked and recovery (in the inoculated)—have been calculated by the "four-fold table" method of Professor K. Pearson. The probable error of these values has been assumed to be three times the error found by the formula $E_r = \cdot 67449 (1 - r^2)/\sqrt{(n-1)}$. In two cases the long method was employed to check these results, but in neither case was the difference material.

The figures contained in Tables I and II were obtained from a census of the whole army, taken by the military authorities. The data are admittedly incomplete owing to the absence of some of the troops on manœuvres or on board ship, and further it is not certain that all cases of inoculation were correctly returned as such. The period covered is from March 1, 1906, to February 28, 1907. Although Major Buist quoted data for the inoculated in the British Isles, these have not been used in this paper. No case of enteric having occurred among the inoculated, the correlation would have appeared high; but the absence of a case amongst a small number of inoculated men has clearly no significance in view of the comparative rarity of the disease, and the small probability of a man, inoculated or uninoculated, being attacked. Tables III and IV refer to local outbreaks in two regiments following their removal abroad. Tables VI and VIII contain statistics obtained from seven large Indian Stations, between January 1 and June 30, 1907; these returns are stated by Major Buist to be the most complete, and are free from most of the errors that are found in the other figures.

TABLE I.

Results of Antityphoid Inoculation. Stations Abroad.
1/3/06 *to* 28/2/07.

	Inoculation		
	+	−	
Not attacked ...	786	30757	31543
Attacked ...	5	193	198
Totals ...	791	30950	31741

$$h = -1\cdot961324, \qquad k = 2\cdot498566,$$

$$\cdot9243r^5 - \cdot56067r^4 + 2\cdot48701r^3 - 2\cdot45024r^2 + r + \cdot00202 = 0,$$

$$r = -\cdot0020 \pm \cdot0114.$$

TABLE II.

Indian Stations. 1/3/06 *to* 28/2/07.

	Inoculation		
	+	−	
Not attacked ...	2122	37113	39235
Attacked ...	8	770	778
Totals ...	2130	37883	40013

$$h = -1\cdot142560, \qquad k = 2\cdot065319,$$

$$-\cdot18698r^6 + \cdot21417r^5 + \cdot06927r^4 + \cdot87398r^3 - 1\cdot66701r^2 + r - \cdot16165 = 0,$$

$$r = \cdot2556 \pm \cdot0095.$$

TABLE III. 17*th Lancers in India**.

	Inoculation		
	+	−	
Not attacked ...	148	481	629
Attacked ...	2	58	60
Totals ...	150	539	689

$$h = -\cdot780018, \qquad k = 1\cdot358832,$$

$$-\cdot0109r^5 - \cdot12184r^4 - \cdot055239r^3 - \cdot529956r^2 + r - \cdot34425 = 0,$$

$$r = \cdot4802 \pm \cdot0593.$$

[* The absence in Pretoria of Mr Maynard does not permit me to ascertain from him the source of the total for uninoculated. In Lieutenant Luxmore's Report, *Journal of Royal Army Medical Corps*, Vol. VIII. p. 492, the strength of the regiment is given as 593 including 84 women and children. Of the five officers' wives, three were inoculated; of the 79 remaining women and children *none* were inoculated. This would make the unattacked who were uninoculated about 100 *less* than the number given by Mr Maynard and would *increase* the correlation. The report, however, in its present form is not one from which it is easy to draw any definite conclusions. The actual proportions of the inoculated and uninoculated in the Delhi squad are not given, although it is possible that the visit contributed to the outbreak. It is not clear how far the draft of the regiment numbering 96 which reached India two months later is or is not included in the returns of cases. If wholly uninoculated, it would account for the 96 additional persons in Mr Maynard's table, but some at least appear to have been inoculated (Luxmore, p. 492). If cases of enteric among this draft are included among the last 20 cases reported by Luxmore, then the total 593, given on his p. 492, does not apply to the incidence. Lieutenant-Colonel Leishman writing in the same *Journal*, p. 465, of the outbreak in the 17th Lancers at Meerut says:

"The report of the attached medical officer, Lieutenant Luxmore, furnishes a striking piece of evidence as to the protective effect of the inoculations. .....The uninoculated portion of the regiment served, unintentionally, as 'controls' and the fact that of 63 cases 61 occurred among these controls, and only two among the inoculated men of the regiment, is one the significance of which it is hard to minimise."

According to Lieutenant Luxmore's *Report*, there were only 61 cases (59 uninoculated and two with the first inoculation dose) not 63. Without knowing the totals of inoculated and uninoculated in the regiment it would not be easy to express the significance really borne by Lieutenant-Colonel Leishman's statement. But several other points of view may be suggested of the 150 inoculated; 13 per cent. were officers and officers' wives, whose environment and average age probably differ much from those of the non-commissioned officers and men. Of the 150 inoculated two were attacked; of the 79 uninoculated women and children included on the strength of the regiment only one appears to have been attacked, a rather less percentage than in the case of the inoculated. Further the so-called "controls" cannot be considered as true controls, until it is demonstrated that the men who are most anxious and particular about their own health, the men who are most likely to be cautious and run no risk, are not the very men who will volunteer to be inoculated; thus a spurious correlation may be produced between attack and absence of inoculation. The age frequency of both classes ought to be further given in every report. Clearly what is needed is the inoculation of one half only of the volunteers, equal age incidence being maintained, if we are to have a real control. The subjection of the inoculated and uninoculated to exactly like conditions of service; the exclusion of officers and their wives, and the women and children from the strength on which percentages are based (and the discovery if possible of why these classes are relatively immune!). Useful points even as statistics are now given would be the addition of the age frequencies and the sickness record (other than that of enteric) of the inoculated and uninoculated groups. Until a far higher standard of statistical observation and statistical reduction is adopted, we cannot possibly call, with Lieutenant-Colonel Leishman, the Report of Lieutenant Luxmore a striking piece of evidence as to the protective effect of the inoculations. What is needed at present in the Army Medical Department is a trained statistician alongside the trained bacteriologist. EDITOR.]

TABLE IV.

3rd Coldstream Guards. Cairo 1906—1907.

	Inoculation		
	+	−	
Not attacked ...	330	368	698
Attacked ...	1	13	14
Totals ...	381	331	712

$$h=-{\cdot}088128, \qquad k=2{\cdot}060759,$$

$$-{\cdot}10942r^5+{\cdot}02823r^4-{\cdot}53692r^3-{\cdot}090805r^2+r-{\cdot}40792=0,$$

$$r={\cdot}4987\pm{\cdot}0577.$$

TABLE V.

Transvaal Districts. 1/3/06 *to* 28/2/07.

	Inoculation		
	+	−	
Not attacked ...	219	6690	6909
Attacked ...	5	65	70
Totals ...	224	6755	6979

$$h=-1{\cdot}850840, \qquad k=2{\cdot}325187,$$

$${\cdot}010105r^5-{\cdot}18365r^4+1{\cdot}7815r^3-2{\cdot}151774r^2+r+{\cdot}205165=0,$$

$$r=-{\cdot}1504\pm{\cdot}0237.$$

TABLE VI.

Seven Large Indian Stations. January 1*st to June* 30*th*, 1907.

	Inoculation		
	+	−	
Not attacked ...	2192	7940	10132
Attacked ...	15	173	188
Totals ...	2207	8113	10320

$$h=-{\cdot}793153, \qquad k=2{\cdot}092043,$$

$${\cdot}01296r^5+{\cdot}22566r^4-{\cdot}20874r^3-{\cdot}82965r^2+r-{\cdot}18746=0,$$

$$r={\cdot}2395\pm{\cdot}0188.$$

		r E_r	r/E_r	N
Table V.	Transvaal ...	$-{\cdot}1504 \pm {\cdot}0237$	6·345	6979
Table I.	Stations Abroad ...	$-{\cdot}0020 \pm {\cdot}0114$	0·175	31714
Table VI.	7 Indian Stations ...	$+{\cdot}2395 \pm {\cdot}0188$	12·739	10320
Table II.	Indian Stations ...	$+{\cdot}2556 \pm {\cdot}0095$	26·905	40013
Table III.	17th Lancers ...	$+{\cdot}4802 \pm {\cdot}0593$	8·098	689
Table IV.	Coldstream Guards	$+{\cdot}4987 \pm {\cdot}0577$	8·643	712

Mean $= {\cdot}2203 \pm {\cdot}0649$.
Mean weighted with $r/E_r = {\cdot}2745 \pm {\cdot}0048$.
Mean weighted with $N = {\cdot}1357 \pm {\cdot}0003$.

We see that four of these results give a positive and two a negative correlation; and the mean calculated with or without weighted ordinates is positive. In Tables I, II and V, it will be noted that the number of the inoculated is very small compared with the total, and therefore the probable error of the class group—inoculated and attacked—is large. A small alteration therefore in this group (which is to be reasonably expected in another sample from the general population of the inoculated) would consequently largely affect the value of r. A further defect in these tables is the very uneven distribution between inoculated and uninoculated, which brings the division near the tail of the frequency curve, with its disturbing effect on the value of r. From this point of view the most satisfactory statistics are found in Tables III, IV and VI, but the total number of men included in the two former tables is small. It would appear therefore that Table VI (seven large Indian Stations) is the most satisfactory and it has already been stated that it is for other reasons the most reliable. In this case the coefficient of correlation is sensibly positive and $r/E_r = 12{\cdot}739$ and is significant.

The divergent nature of these results calls for some explanation. To some extent it may be due to want of homogeneity in the material, owing to different methods of inoculation being employed, and to other causes. It does not seem probable that the whole effect can be attributed to the results of random sampling and so other factors that might influence the result must be sought for.

There is little doubt that there is more than one disease covered by the term Enteric or Typhoid Fever. Bacteriologically it is well known that several varieties of para-typhoid bacilli exist and are the specific cause of fevers clinically indistinguishable from typhoid. There is no *a priori* reason for assuming that a vaccine prepared from typhoid bacilli would confer immunity against infection with any of the para-typhoid strains, and therefore in a locality where the ratio of para- to true typhoid infections is high we might expect to find the coefficient of correlation between inoculation and freedom from attack correspondingly lowered.

It is, I think, significant that the two highest correlations, i.e. those of the 17th Lancers and the Coldstream Guards, give very similar results and further that both these regiments suffered from well marked epidemics of typhoid, whereas the other tables contain for the most part the results of sporadic cases, that is, they represent the disease in its endemic form. Now it is well known that typhoid and para-typhoids are clinically indistinguishable, but the latter do not tend to occur in epidemic form so far as is known. We may therefore assume that the two epidemics mentioned were true typhoid, while in the other cases a certain number of para-typhoids are included, and probably in foreign stations many more than would be expected.

Major Statham, R.A.M.C., has, I think, demonstrated beyond all question that in the Transvaal the para-typhoids are quite common. In a consecutive series of cases blood cultures were made from all the patients suffering from typhoidal diseases, and he found that approximately 20 °/₀ of the supposed typhoids were in reality para-typhoids. Again out of a series of 196 cases examined by Widal's method at the Transvaal Government Laboratory, 102 or 52 °/₀ were returned as typhoids, 72 or 37 °/₀ as para-typhoids and 22 or 11 °/₀ as mixed infections with both para- and true typhoid bacilli. That these latter figures represent the actual ratio of distribution is not likely, as it is chiefly in the mild cases that the blood is sent to the Laboratory for examination, and one would expect more "para" cases would be found in this class; yet they serve to demonstrate that the disease is at any rate common in this Colony, and may occur elsewhere with sufficient frequency to materially disturb the statistics bearing on anti-typhoid inoculation*.

I have not been able to obtain any definite figures as to the number of cases of para-typhoid that occur in India, but the following sentence from Major Roberts' *Enteric Fever*, p. 122, is not without interest in this connection. "Out of 1397 admissions to Hospital for enteric in 1904 only 749 were submitted to the ordinary serum test (against *B. typhosus*), of which 526 are declared to have been positive, 198 negative and 25 doubtful. * * * * * * We can only suggest that taking these results as they stand, there is ample room for a large proportion of para-typhoid infections."

If it is permissible to hazard a guess, it would seem likely, from the results found in this paper, that para-typhoids will be found to be relatively more common in South Africa than in India, and that the conflict in the results may be found to be largely due to this cause, although a much larger percentage than that found by Major Statham would be necessary to account for the entire difference. I calculated in Table V the probable error of the Group 5, and deducting this together with 20 °/₀ of its original value the correlation remains negative but very slightly so.

I regret that owing to lack of material I am only able to include two correlation tables showing the relation between inoculation and recovery from attack. They are both from the Indian stations and correspond to Tables II and VI.

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* [The ratio of *B. paratyphosus* to *B. typhosus* in the Hygienic Laboratory, Washington, for typhoid fever in the district of Columbia is given as 1 to 8 or 12 °/₀, but only 27 blood tests were made, and many of these gave no bacilli. *Hygienic Laboratory Bulletin*, No. 44, p. 11, Washington, 1908. EDITOR.]

TABLE VII.

India. 1/3/06 *to* 28/2/07.

	Inoculation		
	+	−	
Recoveries ...	7	669	676
Deaths	1	101	102
Totals ...	8	770	778

$$h = -2{\cdot}315823, \qquad k = 1{\cdot}121288,$$
$$\cdot 01027r^5 + \cdot 44556r^4 + \cdot 18709r^3 - 1{\cdot}29835r^2 + r - \cdot 010804 = 0,$$
$$r = \cdot 0110 \pm \cdot 0725.$$

TABLE VIII.

Seven Large Indian Stations. January to June, 1907.

	Inoculation		
	+	−	
Recoveries ...	12	131	143
Deaths	3	42	45
Totals ...	15	173	188

$$h = -1{\cdot}406510, \qquad k = \cdot 708378,$$
$$-\cdot 01003r^5 - \cdot 10598r^4 - \cdot 08122r^3 - \cdot 49817r^2 + r - \cdot 071686 = 0,$$
$$r = \cdot 0745 \pm \cdot 1469.$$

In both cases the coefficient of correlation is positive but negligible in comparison with the probable error. It will be observed that both these tables are from Indian figures, and although the Stations Abroad show a much lower correlation between inoculation and freedom from attack yet the death-rate in the inoculated and attacked is nil. I have therefore omitted this table from my series for the same reason as is given in the case of the English figures mentioned above. This result would rather tend to strengthen the supposition that some of these latter cases are para-typhoids, for the case-mortality is much lower in this disease than in true typhoid; on the other hand it must not be overlooked that the total number of cases is so small that a death is hardly to be expected.

It is of interest to note that although these two tables give a zero correlation, yet both the groups from which these figures are obtained give a sensible positive correlation in respect to inoculation and freedom from attack. This opens up an important question in the study of immunity. May a process which gives no protection after attack reduce the chance of attack? These tables are too small to draw any definite conclusion from, and although there is unassailable evidence as to the value of vaccination even when small-pox has been contracted, yet the two processes are not identical, and it is I think safe to say that there is no *a priori* reason for assuming that such a state of affairs might not be.

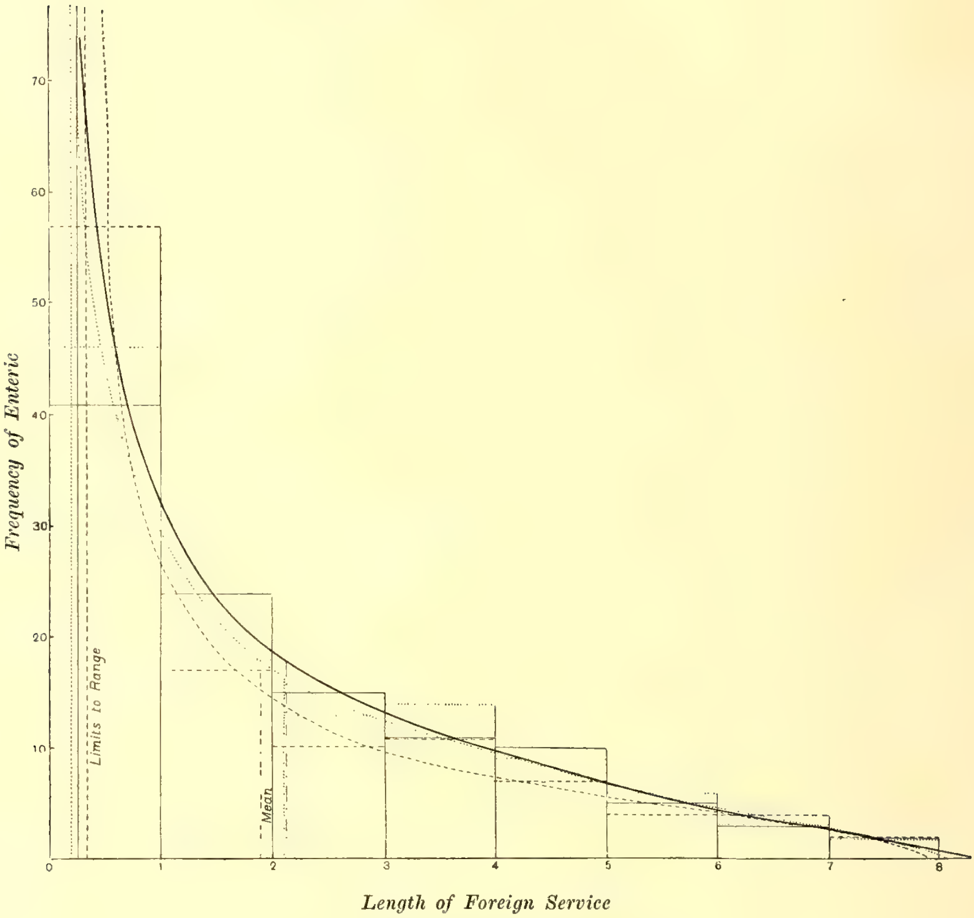
In addition to the figures already dealt with, there is in Major Buist's paper another table apparently compiled to show that the protection conferred by the process does not attain its maximum efficiency at once. Thus we find it recorded that out of 112 men attacked after inoculation 57 contracted the disease within one year, 17 within two, 10 within three, 7 within four, 4 within five, 4 within six, and 2 after the lapse of seven years. As the majority of the men inoculated left for foreign stations shortly after the event, I sought for a comparison amongst the uninoculated in foreign stations to see if there were sufficient grounds for this suggestion. The only figures that I could find that were at all comparable were given in Major Roberts' *Enteric Fever*, obtained from the Army Medical Records, for the troops in India for the years 1900–3. Those given by Major Buist covered a period from 1900–7. The largest proportion of the inoculations took place in the early part of this period. It is true that many of these cases were contracted in South Africa, and that the Indian statistics include some inoculated men, but I do not think that either of these sources of error robs the comparison of all value; for the relative number of the inoculated to the uninoculated is small, and both in South Africa and in India the disease is endemic in a way that it is not in the British Isles, and, further, towards the end of the Boer War enteric fever was probably as rife in South Africa as it ever is in India.

For this comparison to be entirely satisfactory it would be necessary that all the men inoculated should have completed seven years. As this was not the case, I attempted to adjust the figures so as to compensate for this deficiency. Unfortunately each year did not supply an equal number of men, the largest proportion occurring in the first two years of the period, i.e. 1900 and 1901. It was also found impossible to alter the last two groups except by inspection of the plotted figures, as the number of cases occurring in them was so small that the error of one case would make too great a proportional difference. I think the result is an over-correction, and the truth will lie between the crude figures and the corrected ones. It will be seen that neither curve is different in type from that given by the Indian data, and that all the constants only vary by an amount that might certainly be due to random sampling in a homogeneous population. The type is that of Professor Pearson's Type I, and the following are the equations to the curves.

Indian $$y = 23{\cdot}62\left(\frac{x}{6{\cdot}479} - 1\right)^{-\cdot 4105}\left(1 - \frac{x}{14{\cdot}538}\right)^{\cdot 9211};$$

Buist's $$y = 3{\cdot}726\left(\frac{x}{15{\cdot}669} - 1\right)^{-\cdot 6521}\left(1 - \frac{x}{8{\cdot}09}\right)^{\cdot 3367};$$

Buist's modified $$y = 19{\cdot}96\left(\frac{x}{9{\cdot}494} - 1\right)^{-\cdot 4246}\left(1 - \frac{x}{15{\cdot}426}\right)^{\cdot 7793}.$$



— Roberts' Enteric Indian Curve.
- - - Buist's Enteric Curve.
······ Buist's Modified Enteric Curve.

Service	Calculated Ordinates		
	I.	B.	B. M.
·5	52	68·7	45·1
1·5	23·2	18·7	21·5
2·5	15·7	11·8	15·1
3·5	11·4	8·6	11·1
4·5	8·2	6·6	8·2
5·5	5·7	5·1	5·8
6·5	3·8	3·8	3·9
7·5	1·7	1·7	1·7

The chief constants of the curve are given below:—

	Indian*	Buist's	Buist's modified
Mean	2·1577 ± ·0147	1·8928 ± ·1193	2·1273 ± ·1193
Standard Deviation	1·82310 ± ·0143	1·8725 ± ·0844	1·8580 ± ·0844
$\sqrt{\beta_1}$	1·03961 ± ·01974	1·2896 ± ·1561	1·0025 ± ·1561
β_2	3·23810 ± ·9395	3·6814 ± ·3122	3·1054 ± ·3122
κ_1	−2·7660	−3·6267	−2·8040
κ_2	− ·3885	− ·5640	− ·3551
Start	·2639	·3320	·1889 years
End	8·3229	7·9110	8·1210 years

It will be seen from these figures that the three curves are not very dissimilar and that the Indian has a value intermediate between the other two. It seems safe therefore to assume that in the cases quoted by Major Buist we are dealing with a sample of the general population not modified in this respect by inoculation, and that no deductions in support of this process can be drawn from this distribution.

From a study of these figures it would appear that the case for anti-typhoid inoculation is at present not a strong one, and before the real results of the process can be determined with any approach to satisfaction the effect of diseases of the para-typhoid type must be eliminated from the returns by careful diagnosis based on bacteriological processes. Although the correlation is not nearly as high as is usually found for the cases of "recovery from small-pox in the vaccinated," the general trend is to show a positive result in favour of the process, and this is particularly so in the examples where it is most reasonable to assume that one is dealing with true Typhoid Fever. Whether a polyvalent vaccine would be more efficacious or not, is a matter for the expert bacteriologist; but I feel convinced that so long as the para-typhoidal diseases are overlooked, either in the prophylactic treatment or in the statistics, more definite results will not be obtained. At present the statistics are not all that might be desired, but I understand that the Army authorities are making a special effort to obtain reliable figures in the future, and it is only from this source that we can hope to obtain sufficient data.

My excuse for presenting this paper at the present time in its admittedly incomplete form is the importance of the subject, not alone to the Military Authorities, but to all those living in the South African and other colonies, where Enteric Fever is a perennial scourge, which if regarded only from its financial aspect is a very serious question.

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* The probable error in the Indian figures is calculated taking $N = 7000$ as this was approximately the actual number from which the ratios were reduced. In the other cases $N = 112$.

A BIOMETRIC STUDY OF PHAGOCYTOSIS WITH SPECIAL REFERENCE TO THE "OPSONIC INDEX."

By M. GREENWOOD, Junr., L.R.C.P., M.R.C.S., and
J. D. C. WHITE, M.A., M.D. Cantab., L.R.C.P., M.R.C.S.

FIRST MEMOIR. ON THE FREQUENCY DISTRIBUTIONS OF PHAGOCYTIC COUNTS.

(*From the London Hospital Statistical Laboratory.*)

Perhaps no event since the famous studies of Metchnikoff has done so much to concentrate attention upon the phenomena associated with phagocytic action as the appearance of Wright and Douglas' papers announcing the discovery of "Opsonins" in blood serum*.

Since the original communications appeared, a literature of respectable dimensions has accumulated, and controversies, which show few signs of abating, have been provoked.

Looking at the matter from the standpoint of a clinician, it would appear that the controversialists are ranged in two camps. On the one hand, Sir Almroth Wright and his pupils maintain that we possess in the determination of the "opsonic index" not only a reliable means of diagnosis and prognosis in cases which cannot be elucidated by the time-honoured methods of clinical examination, but the ability to regulate therapeutic procedures with a precision and delicacy which, if still leaving somewhat to be desired, have been hitherto unattainable.

On the other hand, investigators not less numerous and almost as trenchant, have asserted that opsonic determinations are altogether unreliable for purposes of diagnosis, prognosis or treatment.

In view of the great practical value which must attach to the method if the claims of Sir Almroth Wright be well-founded, we have undertaken an analysis of data which seemed likely to yield information of importance as to the reliability of opsonic determinations as at present made.

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* *Proc. Roy. Soc.* 1903, LXII. p. 357; 1904, LXIII. p. 728.

We do not think it necessary to examine in detail the various conflicting statements which have appeared, because we hope to show that:—(1) the problem is essentially a statistical one: (2) it is statistically complex and cannot be solved without such a preliminary analysis of the data as has, up to the present, not been attempted.

In order to establish these propositions to the satisfaction of a biometric reader, it will be necessary to describe in the fewest and simplest words the way in which an "opsonic index" is determined.

In consequence of Wright and Douglas' work, it is believed that the power of ingesting and rendering harmless foreign organisms—with which certain of the white blood cells, the phagocytes, are endowed—depends upon the presence in the tissue liquids, especially the blood plasma, of a substance certainly complex and probably specific, termed an "opsonin" (feast-preparer). This opsonin renders the foreign organism apt to be ingested and destroyed by a phagocyte. The difference between the phagocytic powers of a normal and a diseased person is due far more to differing amounts of opsonin in their respective tissue liquids than to differences in the phagocytic cells. Thus it is said that, with certain relatively unimportant exceptions, if A be normal and B diseased, B's leucocytes mixed with A's serum are as strongly phagocytic as A's own leucocytes in A's serum, and conversely.

If one wishes to determine the opsonic power of a man's blood with reference to, say, the tubercle bacillus, the following process is adopted*.

A sample of the patient's blood serum is taken, further a sample of normal corpuscles which have been washed free of adherent plasma, and an emulsion of dead tubercle bacilli; serum, corpuscles and bacillary emulsion being taken in equal parts. The three constituents are now mixed together and incubated at body temperature for a definite time. A second mixture is prepared and treated in the same way, except that normal serum (that generally of the operator, or a mixture of several presumably normal sera "pooled") is substituted for that of the patient.

Film preparations are then made from each mixture and so stained that the tubercle bacilli can be readily detected within or without the cells; with the ordinary technique, the red colour of the bacilli is well shown up against the blue nuclei and faintly blue cytoplasm of the leucocytes.

A variable number of leucocytes, in most laboratories neither less than 50 nor more than 100, is now counted on each of the two films and the number of bacilli per cell recorded. Let us suppose that the leucocytes mixed with the normal serum contained 100 bacteria in 50 cells, while those mixed with the patient's serum contained 50 bacteria in the same number of leucocytes, then the patient's opsonic index is said to be 50/100 or 0·5.

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* The whole of our work is based upon determinations made relatively to the tubercle bacillus, and the phrase "opsonic index," when used without qualification, is to be understood as meaning opsonic index for tubercle. We are not prepared to say how far our conclusions are valid for other opsonic determinations.

This brief description is perhaps enough to establish the statements as to the essentially statistical nature of the problem advanced above. Since the fundamental point is whether and how far the character of the cells counted (a sample liable to the full error of random sampling) describes fairly that of the whole population of cells from which it is drawn, the question can only be adequately treated by a statistician. It is equally clear that the problem is complex because it involves several variables, no one of which is exactly known.

In the first place, the thickness of the bacillary emulsion, i.e. the number of bacilli per unit volume of emulsion, is necessarily different from day to day, because no satisfactory method of standardisation has yet been discovered. For instance, if on one occasion the emulsion contained a bacilli per unit volume, then it is impossible to insure that in subsequent determinations the emulsion will be of the same strength. Such variations are often large.

This difficulty is met by the assumption that if, with an emulsion of concentration a bacilli per unit, cells in normal serum ingest A bacilli per leucocyte and cells in pathological serum B bacilli per leucocyte, then with an emulsion of concentration $n.a$, the average cell contents will be respectively $k.A$ and $k.B$ where k is some constant.

It will be noticed that this assumption involves two distinct assertions, viz.:—(1) that the normal opsonic power is constant: (2) that given (1) nothing is changed relatively when the number of bacteria to be ingested is altered.

These questions have recently been discussed by Dr Alexander Fleming[*], to whose statements we shall briefly refer.

In the first place, Dr Fleming cites the results of Dr Bulloch[†], who estimated the indices of 84 apparently normal persons in terms of his own serum. 75 were between 0·9 and 1·1, the other 9 falling within the extreme limits of 1·2 and 0·8.

But a constant ratio, i.e. a constant opsonic index, would be found if the opsonic content of each serum varied from day to day in the same direction. The criticism is perhaps of little importance, but the point must be remembered.

A somewhat different process has been used in Sir Almroth Wright's laboratory and we quote Dr Fleming's description of it[‡].

> "In the routine work of the laboratory, the controls used in connection with the estimation of the tuberculo-opsonic indices of our patients are furnished by the various workers in the laboratory, or, it may be, by interested visitors and students, and these are used in the proportion of one control to every eight or ten patients' sera. Thus, in each day's work, there are three or four normal sera used, and each observer who engages in counting any of the slides, counts at least two, but even three or more of these controls.

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[*] "Some Observations on the Opsonic Index with Special Reference to the Accuracy of the Method and to some of the Sources of Error" by Alexander Fleming (*Practitioner*, 1908, Vol. 80, pp. 607—634).

[†] W. Bulloch, *Trans. Path. Soc.* 1905, Vol. 56, p. 334.

[‡] Fleming, *op. cit.* p. 608.

> "In this way a double check on the accuracy of working is obtained, as not only is one control serum checked by the others, but one observer's count is at the same time checked by another's count of the same slide.
>
> "The figures in the table represent the opsonic indices which are arrived at in exactly the same way as in dealing with a patient's blood, the actual phagocytic count of the slides being divided by the mean of the counts of all the controls counted."

Of 635 estimations made in this way 5 gave a reading of less than 0·9, 64 fell between 0·9 and 0·95; 488 were between 0·95 and 1·05, 68 between 1·05 and 1·1, and 10 were greater than 1·1.

We take this method to be superior to that employed by Dr Bulloch, since the "normal" mean value for any given day is deduced from more than one count made with more than one person's serum. We must, however, remark that the results to be described in this memoir seem to indicate a very considerable range of variation, whether the serum used be taken from a normal or diseased person, and that our work refers to much larger samples than those considered by either Dr Bulloch or by Dr Fleming.

Dr Fleming also considers various sources of error which, being dependent upon technical manipulations, hardly fall within our province, but it is right for us to summarise them as evidence of the complexity inherent in the opsonic problem from whatever standpoint it may be regarded.

(*a*) Agglutination of the washed *red* corpuscles increases the amount of phagocytosis, and the error thus introduced may be large*.

(*b*) If red corpuscles are taken up with the serum, the amount of phagocytosis is reduced.

(*c*) Blood capsules left widely open for several hours give untrustworthy readings.

We now turn to the actual counting of the cells, a vital matter, in respect of which Dr Fleming's views are so peculiar that we quote them *in extenso*:

> "Having now discussed some points in connection with the different factors in connection with the estimation of the opsonic index, we turn to another most important part of the technique, namely the counting of the number of bacteria which have been ingested by the leucocytes. Needless to say, this must be done with great care and conscientiousness, otherwise errors will creep in. In this connection it should be pointed out that it is a great mistake to have any arbitrary number of leucocytes which one counts, neither counting more nor less whatever the conditions may be. A number of leucocytes, which will give one a good average of a slide with one emulsion, will not furnish a true estimate of a slide with another emulsion which may be uneven or clumpy. If all emulsions were perfect, it would be very easy to say that a certain number of leucocytes per slide would furnish a result differing from the true reading by not more than ten per cent., but, unfortunately, in practice emulsions are rarely perfect, and, as life is short, one wants to get a true estimate of the slide without counting very large numbers of leucocytes such as have been advocated in one or two quarters. It is here that experience will come in and enable a person, who counts intelligently, to obtain a good average with a smaller

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* See Fleming, *op. cit.* p. 617.

number of cells than a beginner would require. If a person counts simply mechanically every leucocyte he meets and fails to bring any intelligence to bear on the subject in hand, however much care he may have taken to avoid error, if his emulsion is not perfectly even (which is uncommon), he will have to count a very much larger number of cells before he has a trustworthy count of the slide*."

Now the statement that, given a "perfect" emulsion, it would be easy to say that a certain number of cells would furnish a result within ten per cent. of the true reading, can only be valid if the nature of phagocytic frequency distributions were exactly known, i.e. whether such distributions are "normal" or "skew," and in the latter event, of what type and possessing what degree of skewness.

To the best of our knowledge, the present memoir contains the only attempt to answer these preliminary questions which has been made.

Again, why "intelligent" counting of a few cells should give better results than "mechanical" counting of many, is not obvious unless we are furnished with some stringent definition of the word "intelligent."

It is difficult for us to form a mental picture of a worker who, while failing "to bring any intelligence to bear on the subject in hand," *at the same time*, takes the greatest care to avoid error. We imagine that an intelligent worker, using the word intelligent in an ordinary way, will only reject cells so badly stained, broken up, massed together, or containing such clumps of bacteria that either the outline of the cell or the number of bacteria it contains cannot be accurately gauged.

Of papers expressing an unfavourable opinion of the opsonic method, the most extensive is that by Drs Strangeways and Whiteman and Miss Fitzgerald†.

These observers found very great differences between the means of phagocytic counts from batches of 50 or 100 cells taken from the same slide, i.e. mixed with the same serum. They also found that two capsules of the same blood, drawn at the same time and treated in the same manner, gave widely divergent readings. Similarly, opsonic indices of the same blood, estimated by different persons in terms of the same control, varied considerably.

The authors of the paper just mentioned did not avail themselves of modern statistical methods of analysis. Their conclusion that opsonic determinations are subject to an error of 100 per cent. does not, using the word error in any exact sense, follow from their work. There is, for instance, an evident confusion between the extreme variations in the range of values exhibited by the separate counts and the mean variation.

Further, a comparison of groups each of 100 cells from the same slide is not *necessarily* the same thing as comparing counts of 100 each from a separate slide. There is *possibly* here a fallacy analogous to that involved in the assertion that measuring the entire adult population of a village will give as good a measure of racial characters as a sample of the same number of persons drawn indiscriminately from a whole population.

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* Fleming, *op. cit.* p. 627.

† "An Inquiry into the Value of the Opsonic Index" by M. P. Fitzgerald, R. I. Whiteman and T. S. P. Strangeways. (*Bulletin of the Committee for the Study of Special Diseases*, Vol. I. No. 8, Aug. 1907, Cambridge University Press.)

Although we cannot satisfy ourselves that Dr Strangeways and his colleagues have demonstrated that the opsonic method is unsound, their paper marked, in our opinion, an important step in advance. They were, we think, the first students of the method to realise the necessity of counting large numbers of cells, in some cases extending their counts to 2000 cells, and to attempt to put the matter upon an adequate statistical or arithmetical basis.

Should the present memoir be of any service to subsequent investigators, it will be owing to the kindness of Dr Strangeways, who has placed all his valuable material at our disposal. No useful purpose would be served by a further attempt to summarise the literature of opsonic determinations*. To do so would entail the recitation of absolutely irreconcilable conclusions, based, so far as we can judge, upon but slender evidence.

The accounts to which we have more particularly referred, ably present the opinions of two schools of observers, and will enable the statistician "to see the cloud of doubt in which things are wrapped." We shall now describe the manner in which we have attempted to elucidate the points at issue.

The practical man has a right to demand that a biometric problem should first be attacked in the most simple and direct manner. Only when simple methods are demonstrably insufficient are we justified in adopting a more elaborate and less direct plan.

The most direct way to test the value of opsonic determinations is to compare the differences between the mean of a "control" phagocytic count and the respective means of patients' counts, made on the same day and with the use of the same emulsion, with the probable errors of such differences calculated *on the assumption of a normal distribution of the observations.* It could then be seen whether the indices corresponded to significant differences of mean values.

Now, at the London Hospital, one or two control counts of 75 cells which have been in contact with the serum of the investigator, serve as a standard by which other counts, each of 75, made on the same day are measured.

The actual figures having been preserved, numerous series were available for analysis, thanks to the kindness of our colleague, Dr Western.

Assuming the normality of the distributions, results were obtained, a few of which are reproduced in Table I.

At first sight these results suggest that variations of say ± 20 per cent. in the mean value, or opsonic indices above 1·2 or below 0·8, are significant were it not for the existence of a striking peculiarity.

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* Reference may be had to Manwaring and Ruh, *Journ. of Experimental Medicine*, Vol. IX. 1907, p. 473. C. E. Simon, *ibid.* p. 487. C. F. Bolduan, *Long Island Medical Journal*, Vol. I. 1907, No. 10 and *Medical Record*, Jan. 4, 1908.

TABLE I.

Figures from London Hospital tested on Basis of Normal Distribution.

5 xi. 07. "Control" Mean 2·053 ± ·1093.

Expt. No.	(1) Mean Bacilli	(2) Difference Δ from "Control" Mean	(3) Opsonic Index	(4) Δ/*E* *
2	1·33	·72 ± ·16	0·65	4·50
3	2·21	·16 ± ·16	1·08	1·02
5	2·57	·52 ± ·18	1·25	2·89
7	2·27	·21 ± ·16	1·10	1·31
11	1·95	·10 ± ·16	0·95	0·63
		2 xi. 07. "Control" Mean 3·453 ± ·0324.		
4	4·05	+ ·60 ± ·25	1·17	2·43
5	3·43	− ·02 ± ·22	0·99	0·09
6	3·95	+ ·50 ± ·25	1·14	2·00
7	3·07	− ·38 ± ·24	0·89	1·58
10	4·71	+1·26 ± ·25	1·36	5·04
11	3·48	+ ·03 ± ·24	1·01	0·13
12	3·63	+ ·18 ± ·24	1·05	0·75
13	3·43	− ·02 ± ·24	0·99	0·08

No statistician glancing at the figures could help being struck by the apparent skewness of the distributions.

We give in Table II. four examples taken at random.

TABLE II.

Four Examples of Phagocytic Counts from London Hospital Records.

Number of Bacilli per cell	Frequency of Cells			
	1	*2*	*3*	*4*
0	3	5	9	2
1	15	4	18	3
2	22	7	18	9
3	26	15	23	11
4	23	16	31	11
5	25	13	21	14
6	17	7	10	9
7	5	2	10	9
8	9	4	3	3
9	5	1	5	3
10	0	1	2	1
11	0	0	0	0
12	0	0	0	0
Totals	150	75	150	75

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* *E* = probable error of Δ.

While an analysis of counts of 75 would not enable us to settle the type distribution, yet in the face of such figures it is not justifiable to assume that the distributions are normal.

But if the distribution of the variates round the mean of a sample is not Gaussian, then to assume that the curve representing the locus of means obtained from such samples is normal, and to use the ordinary notation for "probable errors," would be equally unjustifiable.

In discussing a kindred subject in a recent number of this journal*, Pearson remarks—"A further point not yet discussed, but of some importance, is the significance of the 'probable error' at all when we are taking the standard deviation of standard deviations in the case of very skew material. How far does the distribution of standard deviations follow a normal curve?"

In a valuable memoir†, "Student" has investigated the distribution of the means of small samples derived from a normal population, and has shown that such distribution is not Gaussian. The problem has not yet, we think, been studied in the case of skew material. Theoretically it is difficult because the analysis becomes troublesome when we have to deal with a case in which, among other things, the odd moments do not vanish; the problem is nevertheless of such importance that we hope to publish later some theoretical considerations.

However this may be, whether we can determine the curve of means with the help of algebraic analysis alone, or whether we are compelled to fall back on directly empirical methods, an essential preliminary is a knowledge of the frequency distributions of phagocytic cells with respect to the number of bacteria contained in them, as determined on statistically adequate samples of the material from which the small working-samples are extracted. When we have this knowledge, the question as to whether the opsonic method be worthy of confidence will be, not solved, but capable of solution.

We hope that this vital point will be clear to the non-statistical reader. Briefly recapitulating—The reliability of the opsonic method turns on whether the mean of the sample measured with the control serum, and the mean of the sample measured with the patient's serum represent adequately the values which would be obtained if a very large number of cells had been counted in each case. We require some measure of the variation in each mean value which may be considered to depend, not upon technical errors, but upon the fact that only a small sample of the population is examined. Until this question is settled, manipulation of the ratios of the means of samples (i.e. opsonic indices) does not seem to be desirable. Such statistical tests as are ordinarily applied to the cases of small random samples are based on assumptions which, in this instance, are arbitrary.

We shall therefore first investigate the frequency distributions of phagocytic cells with respect to the content of tubercle bacilli, determined by the analysis of many distributions, including in each case never less than 400, and in the majority 1000 cells.

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* *Biometrika*, Vol. VI. p. 117.

† *Biometrika*, Vol. VI. pp. 1—25.

Having examined the results thus obtained, we shall give an illustration of the fitting of a curve to the means of samples, each of 25, drawn from a continuous count of 2000 cells, reserving a more complete study of this branch of the subject for a second memoir. Finally, we shall indicate the preliminary conclusions which may be drawn from our work.

The material upon which our analysis is based is two-fold.

As we mentioned above, Dr Strangeways allowed us to use all his data, and from this rich material we have obtained 8 sets of 1000 cells each, and one count of 2000.

In addition, Dr Fleming, at the suggestion of Sir Almroth Wright*, who expressed his willingness to allow material from his laboratory to be submitted to statistical investigation, made for us six counts, the numbers of cells included varying from 400 to 1100. The frequency distributions are given in Table III. *bis*, and the means of the two sets of figures are as follows:—

TABLE III.

Observer	Reference	Number of cells	Mean	Number of graph
Strangeways	I	1000	1·927	1
”	II S. C.	”	1·521	2
”	II C. & S.	”	1·888	3
”	IV	”	1·706	4
”	III	”	2·014	5
”	V	”	2·119	6
”	VII	”	1·851	7
”	VI	”	1·901	8
”	IV	2000	1·689	9
Fleming	T. C.	1000	2·145	10
”	10 Norm.	1010	2·571	11
”	Norm. S. A.	750	3·040	12
”	No. 2	800	2·0825	13
”	T. A.	1100	3·729	14
”	Norm. S. B.	400	3·005	15

A striking difference between the S. and F. counts is the higher mean value found in all the latter.

Owing to the greater ease of counting when but few bacilli are present in each cell, it was formerly recommended that an emulsion should be used which would give about 1·5 bacilli per cell as a mean when normal serum was employed.

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* We desire to express our gratitude to Sir Almroth Wright for allowing the counts to be made and to Dr Fleming for the care and labour entailed in making them.

TABLE III *bis*.

Frequency Distributions.

Bacilli per cell.

Observer	Key Number	*0*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*
Strangeways	I	219	267	219	129	70	50	26	13	5	2	—	—	—	—	—	—	—
”	II S. C.	279	313	192	115	62	20	8	7	2	2	—	—	—	—	—	—	—
”	II C. & S.	198	305	220	124	81	31	17	13	4	5	1	—	1	—	—	—	—
”	IV S. C.	243	290	220	134	54	26	15	9	6	3	—	—	—	—	—	—	—
”	III	188	261	226	153	92	44	19	10	2	3	—	—	1	—	—	1	—
”	V	192	248	202	165	95	47	21	19	4	5	1	1	—	—	—	—	—
”	VII	240	251	212	150	70	38	23	12	2	2	—	—	—	—	—	—	—
”	VI	207	263	223	153	87	35	21	6	3	2	—	—	—	—	—	—	—
”	IV	495	571	445	255	124	55	27	13	9	4	2	—	—	—	—	—	—
Fleming	T. C.	152	239	262	159	96	54	22	11	4	—	1	—	—	—	—	—	—
”	10 Norm.	111	218	210	189	144	73	35	11	11	4	4	—	—	—	—	—	—
”	N. S. A.	41	126	154	164	121	62	36	35	5	2	3	1	—	—	—	—	—
”	No. 2	99	227	208	134	78	34	9	7	3	—	—	—	1	—	—	—	—
”	T. A.	58	107	203	207	174	138	90	49	31	19	10	4	4	1	2	1	2
”	N. S. B.	19	59	98	88	65	37	17	8	5	2	1	—	1	—	—	—	—

Dr Strangeways and his colleagues adopted this plan. As we desired to study the effect on the distributions of raising the mean value, Dr Fleming, at our request, worked with emulsions thicker than those generally employed, so that the effect of the change could, to some extent, be gauged.

We have used the customary method of moments and fitted the curves indicated by the value of κ_2 for each distribution.

Since the actual distributions did not point to high contact at both ends of the range we have not felt justified in applying Sheppard's corrections, and have in all cases worked with raw moments.

Table IV. includes the principal constants for each distribution, together with the values of P*. Table V. contains the equation of each curve, and Graphs 1—15 give the fitted frequency-curves for each worker's material.

We shall first consider Dr Strangeways' *data*.

Before referring to details, however, we desire to point out the completeness with which our results justify the use of Pearson's type curves for biological material of this class. We are now speaking to the practical man with no special knowledge of statistical theory. For him, the real justification of a statistical method must be its capacity adequately to describe samples of material.

This point may be emphasized by reference to a criticism of the methods employed by biometricians.

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* The non-statistical may regard P as a measure of agreement between theory and experiment, the value lying between 1, which marks absolute harmony, and 0. See Pearson, *Philosophical Magazine*, 1900, Vol. 58, p. 175. Elderton, *Biometrika*, 1902, Vol. I. p. 156.

TABLE IV.

Constants of Curves of Type I.

Name	Key Number	Number of cells	Mean	Mode	σ	β_1	β_2	κ_2	m_1	m_2	a_1	a_2	$\beta_2 - 3$	*Sk.*	*P*
Strangeways	I	1000	1·927	·2483	1·7370	1·1996	4·0367	− ·7759	·2250	5·0017	·5715	12·7037	1·0367	·9667	·8345
,,	II S. C.	1000	1·521	·3961	1·4885	1·7839	5·4307	− 3·9486	·7283	29·6566	·9176	37·3466	2·4307	·7557	·8368
,,	II C. & S.	1000	1·888	·5763	1·7209	2·1776	6·1928	− 17·1440	·7182	120·2418	·9692	162·2571	3·1928	·7622	·6900
,,	IV	1000	1·706	·4004	1·6086	1·9095	5·5471	− 3·3407	·5312	22·4231	·7902	33·3574	2·5471	·8117	·4178
,,	V	1000	2·119	·9096	1·8207	1·2561	4·5874	− 2·0896	1·0937	20·4840	1·6084	30·1228	1·5874	·6643	·6415
,,	VI	1000	1·901	·9051	1·6091	·9557	4·0623	− ·1199	1·2262	13·7977	1·6537	18·6085	1·0623	·6316	·9584
,,	VII	1000	1·851	·5301	1·6730	1·0993	4·0562	− ·8929	·5509	7·3527	1·0594	14·1413	1·0562	·7896	·6175
,,	IV	2000	1·689	·5666	1·5825	1·7977	5·5790	− 8·3130	·9593	68·0135	1·1397	80·8012	2·5790	·7093	·6850
,,	IV	80 means	1·691	1·5400	·3278	·4756	3·3185	− ·5073	1·9394	10·0627	4·1977	21·7805	·3185	·4597	·9190
Fleming	T. Chor.	1000	2·145	1·2477	1·6401	·7878	3·8580	− 1·0948	1·6580	15·5284	2·0578	19·2729	·8580	·5471	·8350
,,	10 Norm.	1010	2·571	1·7027	1·8448	·7626	4·0164	− 2·6733	2·8984	48·1737	2·9510	49·0480	1·0164	·4708	·4249
,,	Norm. S. A.	750	3·040	2·2099	1·8927	·5689	3·6214	− 1·0520	2·5978	21·9556	2·9578	24·9981	·6214	·4385	·0314

Constants of Curves of Type V.

Name	Key Number	Number of cells	Mean	Mode	σ	β_1	β_2	κ_2	p	γ	$\beta_2 - 3$	*Sk.*	*P*
Strangeways	III	1000	2·014	1·1697	1·7239	2·0366	7·6447	·7416	12·7535	57·8953	4·6447	·4898	·6004
Fleming	No. 2	800	2·0825	1·4134	1·5397	1·2664	5·6386	·8523	17·5656	91·4681	2·6386	·4345	·8721
,,	T. A.	1100	3·7291	2·7096	2·3820	1·2019	5·3331	1·1097	18·2469	151·1134	2·3331	·4280	·7631
,,	Norm. S.B.	400	3·005	2·2806	2·8207	0·9540	4·8445	1·0747	21·7178	155·3138	1·8445	·3984	·9998

Professor Bruns, in his work on the Theory of Probability, writes:—

> "Es ist nämlich leicht zu übersehen, dass die von uns zugrunde gelegte erweiterte Begriffsbestimmung der K.-G. die ja auch willkürlich ersonnene Reihe zülasst, von vornherein eine andere analytische Behandlung der Funktionen 𝔖 und 𝔅 verlangt. Denn wenn als Verteilungskurve ein vorläufig beliebig gestalteter Linienzug auftreten kann, so ist nicht daran zu denken, dass sich solche Gebilde allgemein einer einfacher Formel unterwerfen lassen. Aus diesem Grund sind für unsere Aufgabe auch die von Pearson angegebenen Formen...unzureichend, obgleich sie in mathematischer Beziehung eine grössere Biegsamkeit besitzen, als das zweiseitige Gesetz (Fechner)*."

A sufficient answer to Professor Bruns is that the skew curves of Pearson describe, and describe well, variation in material from many different sources; of this nearly all the examples obtained in the present research afford a striking illustration. Anyone who takes the trouble to examine the method which Professor Bruns holds (erroneously, as we think) to be theoretically superior, will not need to be told that the generalised curves of Pearson are easier to work within statistical practice. If then they give, as here, admirable results, their superiority cannot be questioned.

Turning to the details, we see that all the S. counts, except III., are examples of Type I. with marked skewness. We also notice, as would be expected†, that the most extreme skewness occurs in the distribution of least range.

It may be remarked that the negative start‡ of the curves (see especially Graphs 5 of Strangeways, 11, 13, 14 and 15 of Fleming) may well have some biological significance. We believe that those who have studied the mechanism by the agency of which foreign particles enter or are brought within amœboid cells, are by no means clear as to its real nature§.

It is not clear that all the cells containing no bacteria represent the same stage of phagocytic power. It will perhaps seem that a true interpretation of phagocytic counts having a large number of leucocytes with zero frequency of ingested bacilli is only possible on the basis of some such analysis as the present. The matter is, however, too conjectural for us to consider it here.

The only exceptional result among the S. data was obtained from III. Here the value of the second criterion required, strictly speaking, a curve of Type IV. Type IV. constants were calculated, but although the curve was a good graphical fit, the value of P was small mainly owing to a want of agreement in the first group. In view of the fact that κ_2 was tolerably close to unity we also tried Type V., and, as will be seen, the result is good, and brings this count into line with the other examples. It is specially to be borne in mind that the change of type occurs at the highest mean value of the series. The interest of this will be clear when we have examined the distributions of Dr Fleming's counts.

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* *Wahrscheinlichkeitsrechnung und Kollektivmasslehre*, von H. Bruns, Leipzig, 1906, p. 111.

† Pearson and Filon, *Phil. Trans.* A. Vol. 191, pp. 282, etc.

‡ The start should not of course be before $-\cdot 5$, the large probable error of range gives little significance to starts even at -1. The technique, however, of Sir A. Wright's laboratory appears to emphasise the extent of negative range.

§ For a readable summary with bibliography, see Weiss, Nagel's *Handbuch der Physiologie des Menschen*, Bd. IV. 1908, pp. 629—665.

Just as before, we find the distributions for Dr Fleming's counts are excellent examples of skew variation, and, with one exception (Norm. S.A.), the fits are good, the values of P being but little inferior to those obtained for the S. counts.

The exception (N.S.A.) is, we think, more apparent than real. The graph is a very fair fit, and one group has been mainly influential on P, adding more than 10 to χ^2. There appears to be definite evidence of anomaly in the group of cells with 7 bacilli.

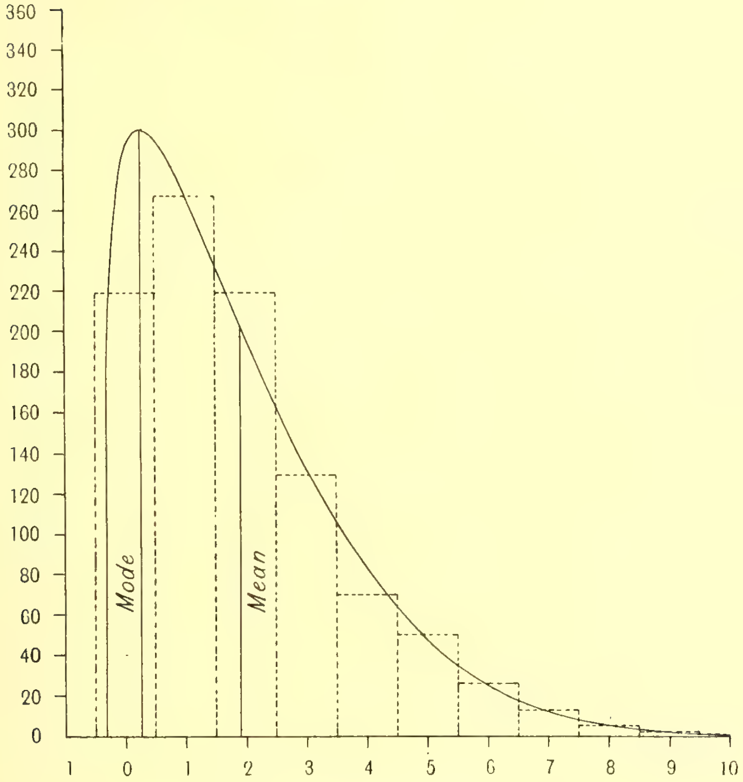
The mean of this count was high, and the sensible frequencies extended to 9 and 10 bacilli per cell. It is notoriously difficult accurately to determine the

TABLE V.

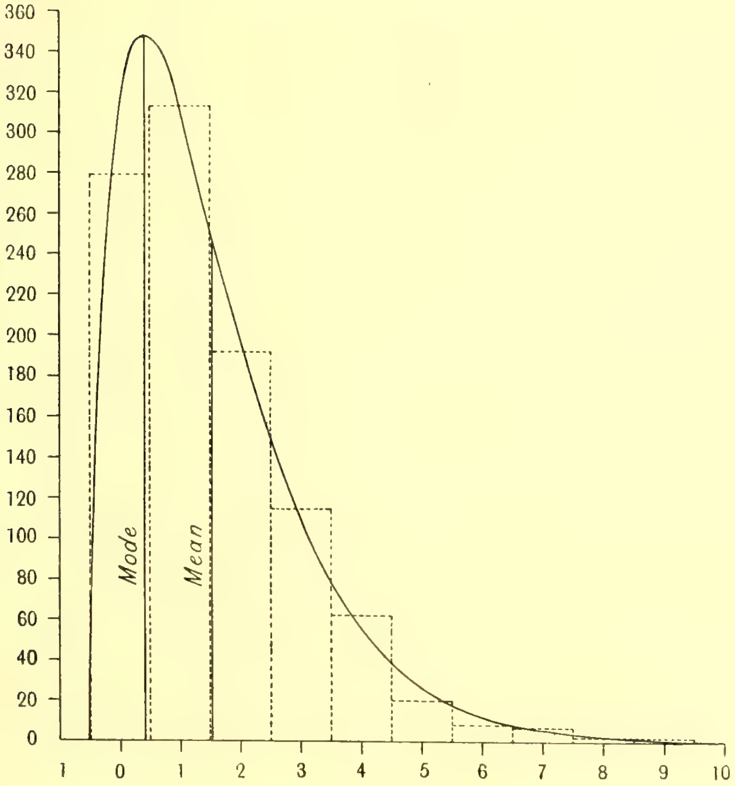
Equations to Curves.

		Graph No.
Strangeways :		
I	$y=299{\cdot}93816\left[1+\frac{x}{{\cdot}5715}\right]^{{\cdot}2250}\left[1-\frac{x}{12{\cdot}7037}\right]^{5{\cdot}0017}.$	1
II S. C.	$y=348{\cdot}0489\left[1+\frac{x}{{\cdot}9176}\right]^{{\cdot}7283}\left[1-\frac{x}{37{\cdot}3466}\right]^{29{\cdot}6566}.$	2
II C. & S.	$y=315{\cdot}83835\left[1+\frac{x}{{\cdot}9692}\right]^{{\cdot}7182}\left[1-\frac{x}{162{\cdot}2571}\right]^{120{\cdot}2418}.$	3
III	$y=\text{antilog } 16{\cdot}3831727\times x^{-12{\cdot}7535}\times e^{-57{\cdot}8953/x}.$	5
IV	$y=335{\cdot}8664\left[1+\frac{x}{{\cdot}7902}\right]^{{\cdot}5312}\left[1-\frac{x}{33{\cdot}3574}\right]^{22{\cdot}4231}.$	4
V	$y=258{\cdot}7307\left[1+\frac{x}{1{\cdot}6084}\right]^{1{\cdot}0937}\left[1-\frac{x}{30{\cdot}1228}\right]^{20{\cdot}4840}.$	6
VI	$y=278{\cdot}51616\left[1+\frac{x}{1{\cdot}6537}\right]^{1{\cdot}2262}\left[1-\frac{x}{18{\cdot}6085}\right]^{13{\cdot}7977}.$	8
VII	$y=284{\cdot}2268\left[1+\frac{x}{1{\cdot}0594}\right]^{{\cdot}5509}\left[1-\frac{x}{14{\cdot}1413}\right]^{7{\cdot}3527}.$	7
IV 2000	$y=643{\cdot}9147\left[1+\frac{x}{1{\cdot}1397}\right]^{{\cdot}9593}\left[1-\frac{x}{80{\cdot}8012}\right]^{68{\cdot}0135}.$	9
Fleming :		
T. C.	$y=264{\cdot}7097\left[1+\frac{x}{2{\cdot}0578}\right]^{1{\cdot}6580}\left[1-\frac{x}{19{\cdot}2729}\right]^{15{\cdot}5284}.$	10
10 Norm.	$y=237{\cdot}05324\left[1+\frac{x}{2{\cdot}9510}\right]^{2{\cdot}8984}\left[1-\frac{x}{49{\cdot}0480}\right]^{48{\cdot}1737}.$	11
N.S.A.	$y=173{\cdot}91942\left[1+\frac{x}{2{\cdot}9578}\right]^{2{\cdot}5978}\left[1-\frac{x}{24{\cdot}9981}\right]^{21{\cdot}9556}.$	12
N.S.B.	$y=\text{antilog } 29{\cdot}9855876\, x^{-21{\cdot}7173}\, e^{-155{\cdot}3138/x}.$	15
No. 2.	$y=\text{antilog } 22{\cdot}603153\times x^{-17{\cdot}5656}\times e^{-91{\cdot}4681/x}.$	13
T.A.	$y=\text{antilog } 27{\cdot}0100681\times x^{-18{\cdot}2469}\times e^{151{\cdot}1134/x}.$	14

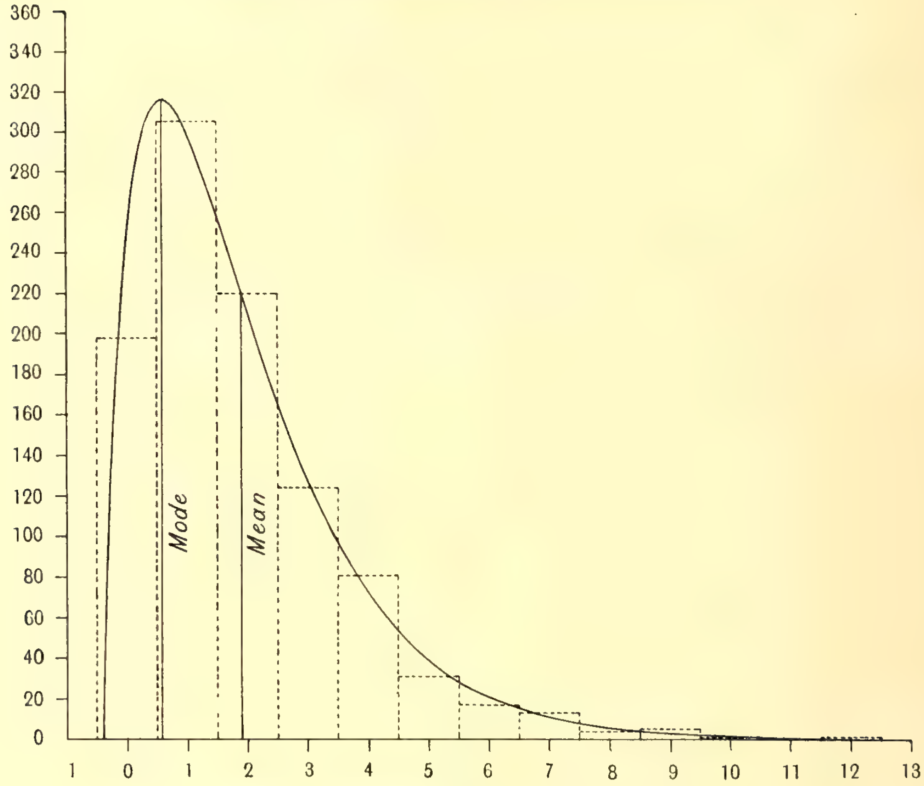
GRAPH 1. Strangeways, T. S. P. I (Slide 7).



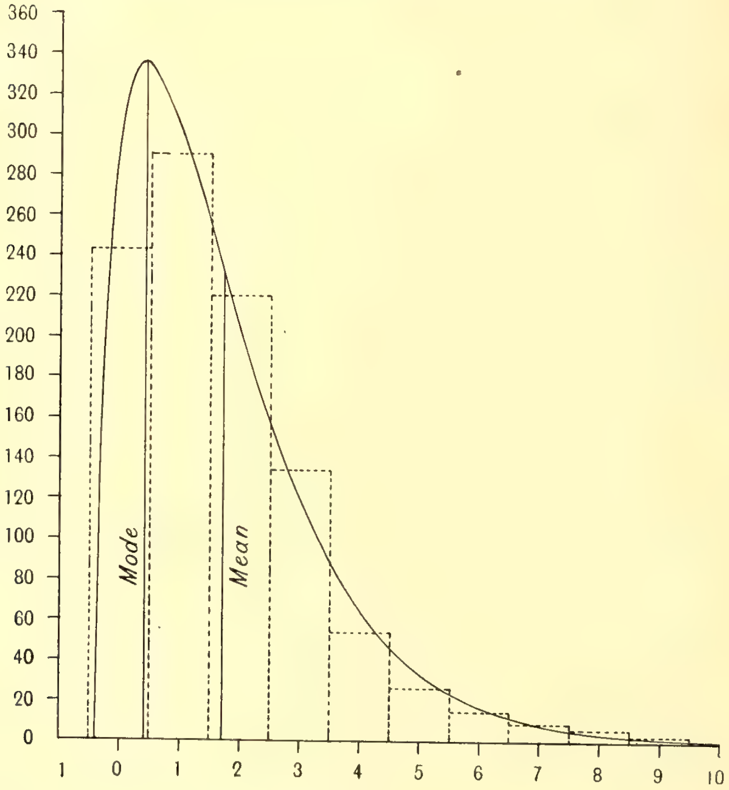
GRAPH 2. Strangeways, Slide II. S. C.



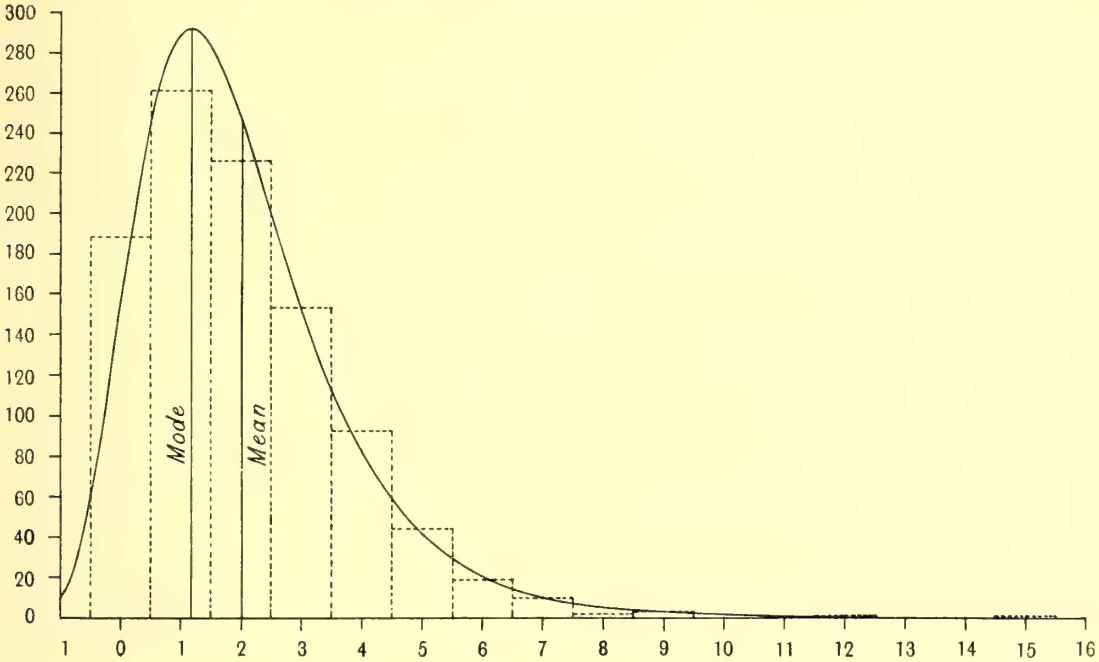
GRAPH 3. Strangeways, Slide II. 1st 1000, C. and S.



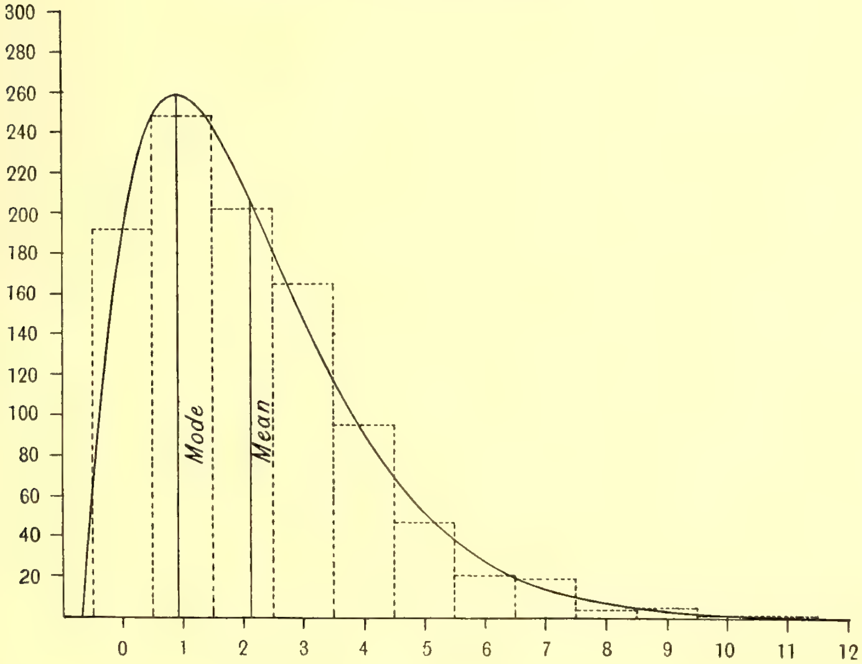
GRAPH 4. Strangeways, IV. S. C. (T. S. P. IV).



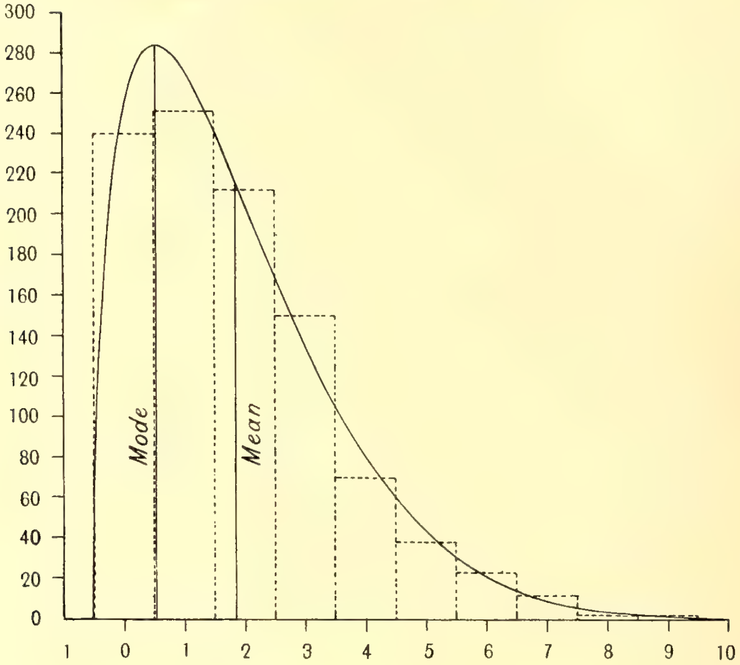
Graph 5. Strangeways, Slide III. S. C.



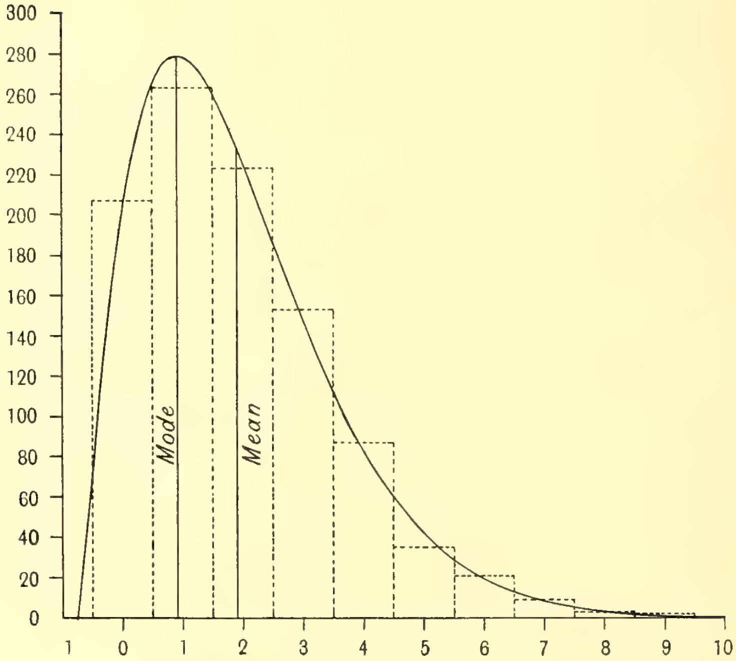
Graph 6. T. S. P., Slide V. S. C.



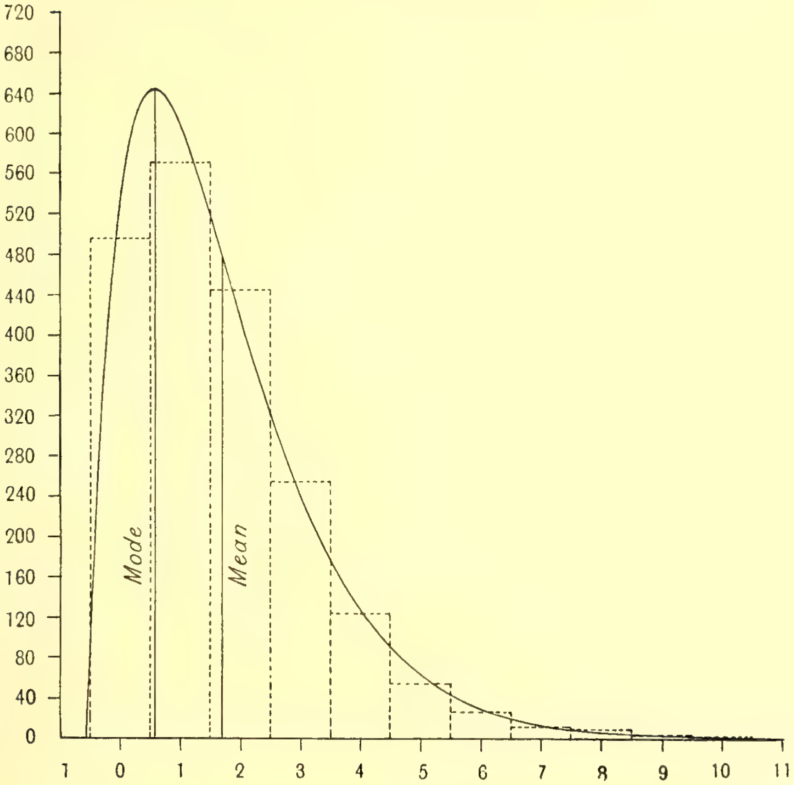
Graph 7. Strangeways, T. S. P., Slide VII. S. C.



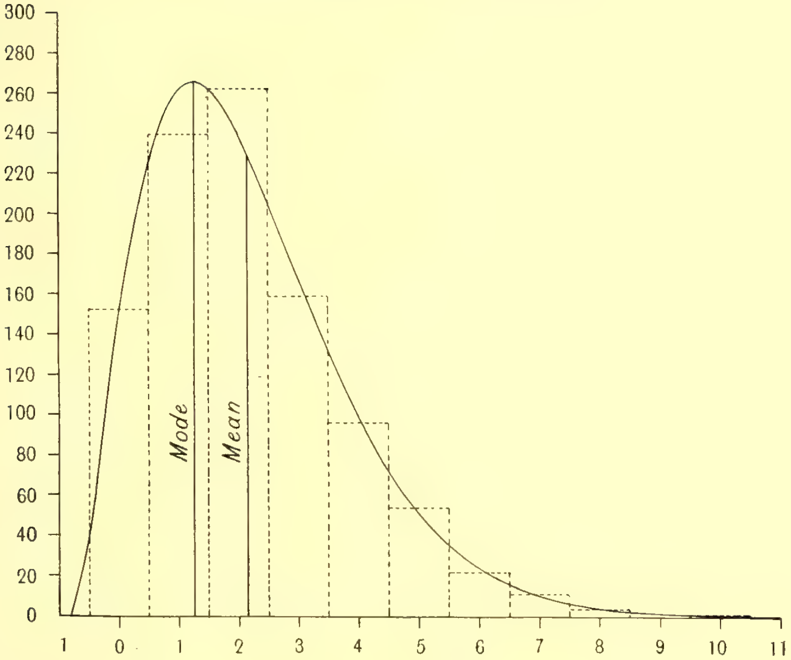
Graph 8. Strangeways, T. S. P. VI.



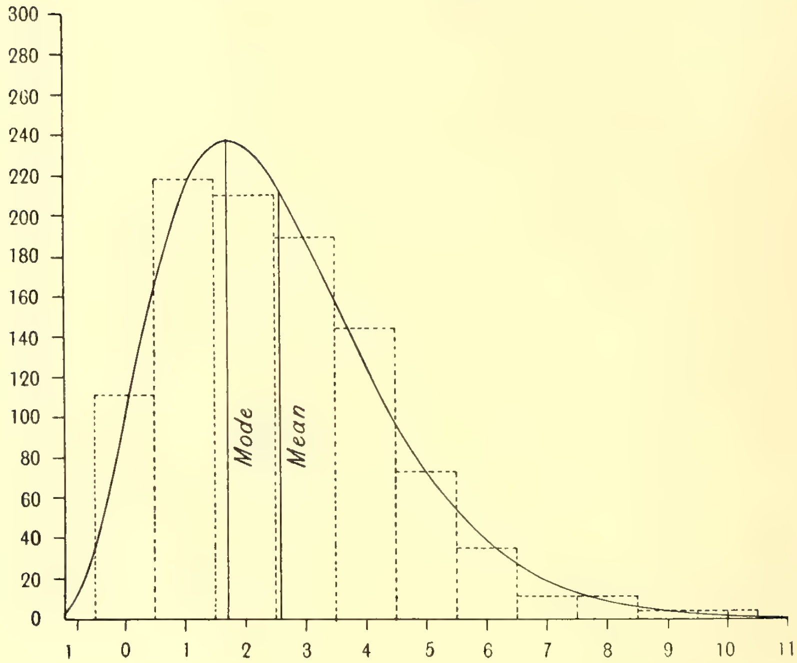
GRAPH 9. Strangeways, T. S. P. IV. (2000 cells).



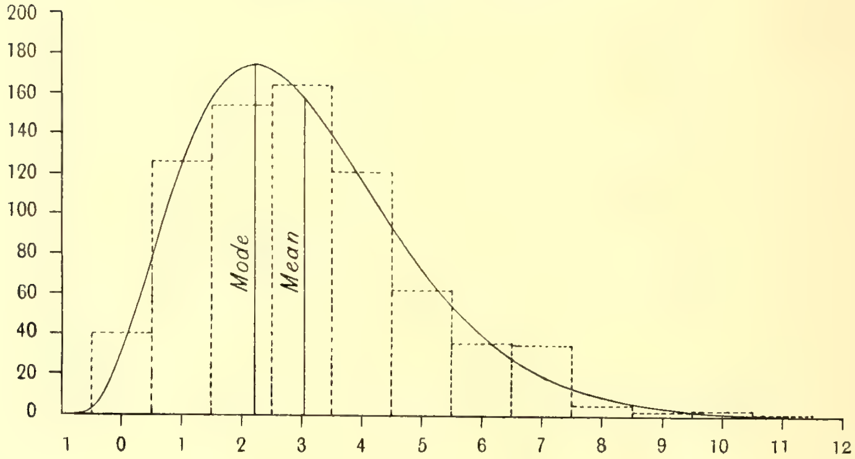
GRAPH 10. Fleming, Tuber. Choroiditis.



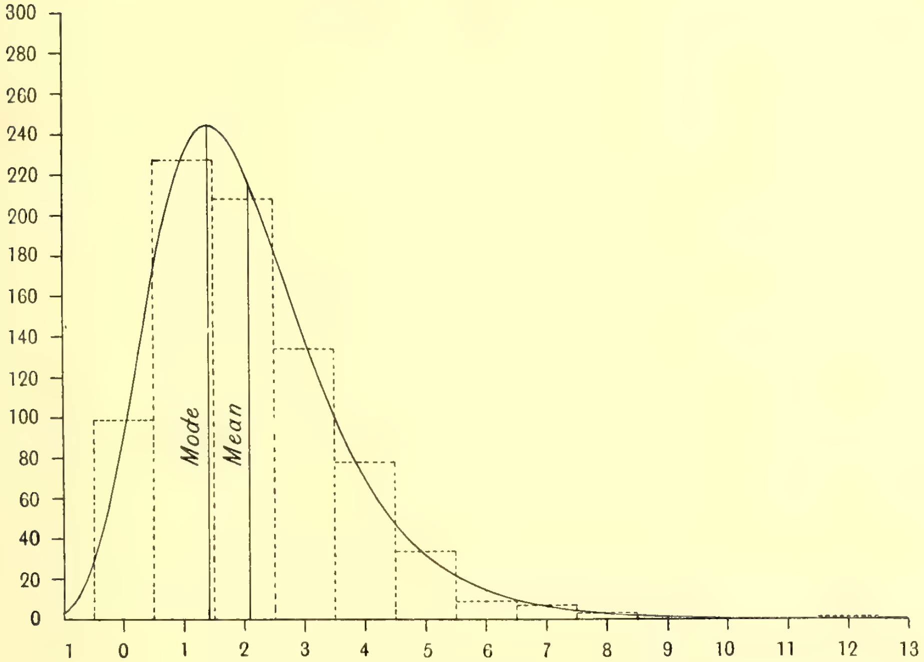
Graph 11. Fleming, No. 10. Normal.



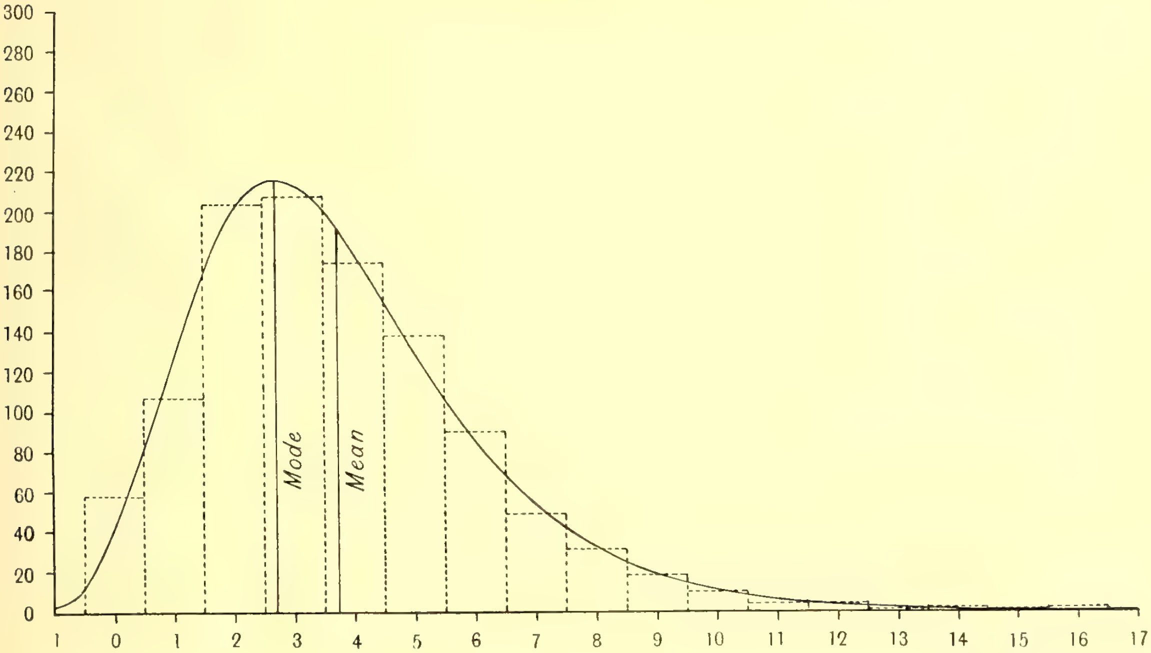
Graph 12. Fleming, Normal Serum A.



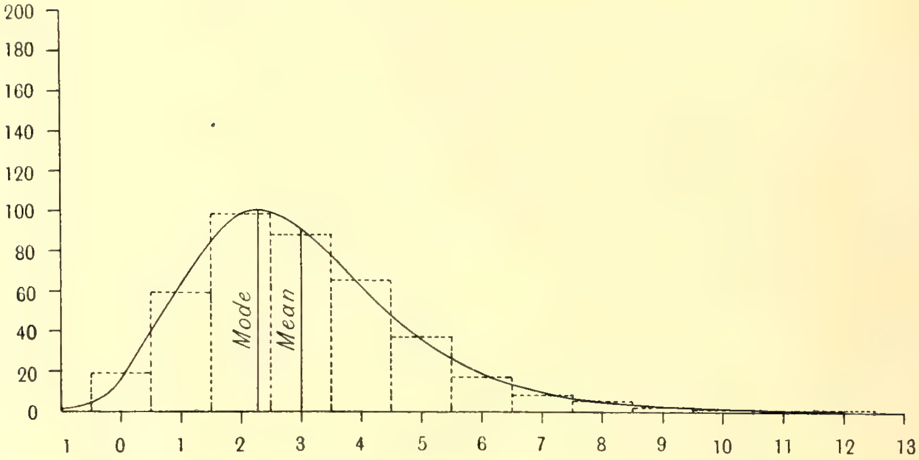
GRAPH 13. Fleming, No. 2.



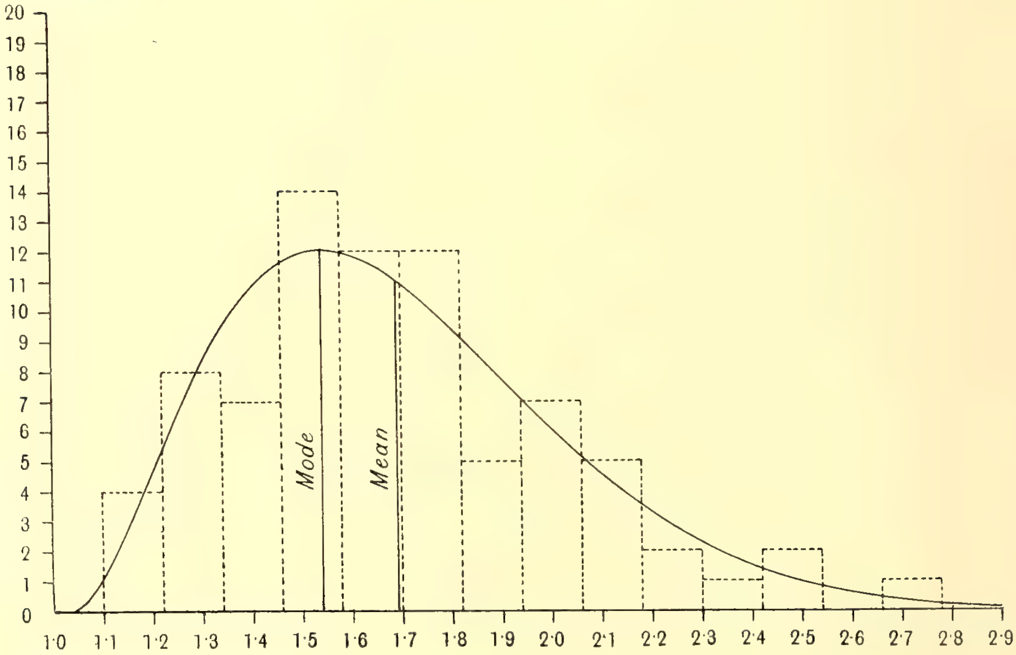
GRAPH 14. Fleming, Tuberculous Arthritis I.



GRAPH 15. Fleming, Normal Serum. Slide B.



GRAPH 16. (S. IV). Curve of (80) Means.



number of bacilli in a leucocyte when the number is large, and this may well account for the irregularity seen at the upper end of the scale where the theoretical curve (Graph 12) gives an obviously more probable distribution than the observed result.

It will be noticed that, in the F. material, Type V. occurs as often as Type I. and is, in all but one case, associated with a high mean value. The *marked* fall of skewness in this set is also of much importance.

Having now presented the main results of our frequency analyses, we are in a position to scrutinise them more closely, touching on certain questions to which they give rise.

First, is our material homogeneous, and does it exhibit nomic variation?

In view of the size of the counts it is reasonable, even without direct calculation, to think that, with the possible exception of N.S.B., the frequency constants are statistically significant. This granted, it is clear that the variation is not only nomic, but of a definite order. Table VI. contains the constants of importance in testing for Gaussian distribution, and it cannot be doubted that random sampling of a Gaussian population could not possibly yield such values.

TABLE VI.

Tests for Normality of Distribution.

Reference Number	$\sqrt{\beta_1}$	$\beta_2 - 3$	Skewness	Modal Divergence
S. I (S. C.)	1·0953 ± ·0522	1·0368 ± ·1045	·9667 ± ·0261	1·6787 ± ·0454
S. II (S. C.)	1·3356 ± „	2·4306 ± „	·7557 ± „	1·1250 ± ·0389
S. II (S. & C.)	1·4757 ± „	3·1928 ± „	·7622 ± „	1·3117 ± ·0450
S. III	1·4271 ± „	4·6447 ± „	·4898 ± „	·8443 ± ·0450
S. IV	1·3818 ± „	2·7516 ± „	·8117 ± „	1·3060 ± ·0420
S. VI	·9776 ± „	1·0623 ± „	·6316 ± „	·9959 ± ·0420
S. VII	1·0485 ± „	1·0562 ± „	·7896 ± „	1·3199 ± ·0440
S. IV (2000)	1·3408 ± ·0369	2·5790 ± ·0739	·7093 ± ·0185	1·1224 ± ·0292
F. N. S. A.	·7542 ± ·0603	·6214 ± ·1207	·4385 ± ·0302	·9301 ± ·0571
F. No. 2	1·1253 ± ·0584	2·6386 ± ·1168	·4345 ± ·0292	·6691 ± ·0450
F. 10 Norm.	·8732 ± ·0520	1·0164 ± ·1040	·4708 ± ·0260	·8686 ± ·0479
F. Tub. Chor.	·8876 ± ·0523	·8580 ± ·1045	·5471 ± ·0261	·8973 ± ·0438
F. Tub. Arth. 1	1·0963 ± ·0498	2·3331 ± ·0996	·4280 ± ·0249	1·0194 ± ·0593

It can of course be said that the description of material by a unimodal frequency curve does not preclude the possibility of its being heterogeneous. Thus a mixture of two or more homogeneous distributions *might*, if the respective modes were close together, be described by a skew frequency curve.

That, with such totals as one or two thousand, we should under these conditions obtain the fits shown, hardly seems sufficiently probable to need investigation here*. We have at least established something more than a *prima facie* case for homogeneity. Secondly, admitting the two sets of frequencies to be definite examples of skew variations of the types indicated, is there any distinct character marking one set off from the other? This question is evidently one of much theoretical and practical interest, and we cannot at present furnish an answer which is entirely satisfactory.

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* It may further be remarked that the rise at a finite angle at the start of the range in nearly all the curves in itself precluded any possibility of a heterogeneity compounded of Gaussian distributions.

We have already remarked on the great diminution in skewness exhibited by the F. material as compared with the S. counts. Although some reduction might be anticipated in view of the higher modal values, which latter are in some measure dependent on experimental conditions (vid. sup. p. 384), we are not clear that this is a complete answer. To determine whether, by random sampling, such a reduction in skewness as we have found would be accounted for adequately by the change in modal value is not easy for the types involved. We have, however, applied a less satisfactory but somewhat easier test.

It was noticed that, although the second moments of the F. distributions were larger than for the S. counts, the increase was not proportional to the mean values. This will be apparent from Table VII., which gives the coefficients of variation.

TABLE VII.

Coefficients of Variation.*

Strangeways :	I	90·14	Fleming :	Tub. Chor.	76·46
,,	II S. C.	97·86	,,	10 Norm.	60·08
,,	III	85·60	,,	Norm. S. A.	62·26
,,	II S. & C.	91·15	,,	No. 2	73·94
,,	IV	94·29	,,	T. A.	63·88
,,	V	85·92	,,	N. S. B.	60·59
,,	VI	84·64			
,,	VII	90·38			
,,	IV (2000)	93·69			

Now it is well known that $$r_{h\mu_2} = \frac{\mu_3}{n\sigma_h \sigma_{\mu_2}}$$

when $r_{h\mu_2}$ is the correlation between mean and second moment, and σ_h, σ_{μ_2} the standard deviations of mean and second moment respectively.

If therefore we calculate σ_h and σ_{μ_2} on the basis of the count of 2000 cells (S. IV 2000), we can form some idea as to whether the observed values of μ_2 for the other counts are such as we should expect, with random sampling, to be associated with the observed values of the mean.

The regression of μ_2 on h was assumed to be linear and the probable value of μ_2 was calculated for 7 S. counts and the results tested for goodness of fit. P was greater than ·99.

The same process applied to 5 F. counts gave $P < ·0004$.

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* It need scarcely be remarked that no stress is or can be laid on the actual values of the coefficients since Mean and Coefficient of Variation are negatively correlated. The table merely illustrates the tendency discussed in the text.

Too much weight must not be assigned to this result, but the indication undoubtedly is that the Strangeways counts are more truly random samples, and therefore better measures of the phagocytic "population" than those of Dr Fleming.

While the evidence undoubtedly points to the conclusion that the difference between the F. and S. series is not wholly to be accounted for by the increased thickness of emulsion employed for the former counts, we are not prepared to assert that the foregoing analysis is sufficient to render the conclusion certain, and we hope to deal with the matter on a subsequent occasion. For these reasons it would not be profitable to discuss the question as to how far differences in technique might operate in depriving a count of its character as a random sample. In justice to Dr Strangeways and his co-workers, however, we must point out that the indirect attacks which have been made* on their competency as observers of phagocytic distributions are entirely unsupported by our investigations. We see no reason whatever for refusing to assign at least equal degrees of importance to the S. data and to those of Dr Fleming.

Gathering up our results, do we find that they affect one's estimate of the practical value of the opsonic test?

One thing is certain; it is not proper to test the distribution either of means or opsonic indices on the basis of a normal population. The population is pronouncedly skew. In view of the extreme skewness of these phagocytic distributions, the mode would be a far better constant for the determination of the opsonic index than the mean; the latter's physical significance has no longer the value attaching to it in the case of normal distributions.

At one time we had a hope† that this skewness, so accentuated in Dr Strangeways' counts of low mean value, might disappear with Dr Fleming's counts, which were rendered higher by the use of a thicker bacillary emulsion; we surmised that the consequent increase in mean and modal values would be associated with an approach to symmetry which might justify the use of the normal curve in practical testing. We did indeed find in the latter curves a less pronounced degree of kurtosis, but the reason of this is a matter of doubt. In any case, even in the F. counts, the skewness is far too distinct to allow the hope of any Gaussian tests being yet valid. Moreover, we have reason to think that Dr Fleming has reached the limit of thickness in emulsion compatible with accurate counting (vid. sup.

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* As for example, that of Dr R. W. Allen, *Vaccine Therapy and the Opsonic Method of Treatment*, London, 1908, 2nd Edition, p. 40. Dr Allen's comparison of workers who find the opsonic method unreliable with those surgeons who are unable to perform certain delicate surgical operations seems to us altogether illegitimate. In this connection we must point out that a reference by Dr Allen (*op. cit.* p. 41) to a preliminary communication by one of us is liable to misconstruction. The statement that the "unavoidable error" involved in opsonic determination is not more than 10 per cent. is not a deduction from our preliminary note but rests entirely on the authority of Dr Allen and other pathologists.

† Greenwood, *Practitioner*, Vol. 80, 1908, p. 641.

p. 388 discussion of N.S.A.). Any test therefore must be based on the full acceptance of the skewness of phagocytic distributions.

Of the consequences of this admission we shall not here speak at length: we are at least justified in pointing out the danger of attaching weight to the evidence of small samples.

There is no ground for the expectation that random deviations in excess or defect of a mean value will occur with equal frequency.

Again, distributions with high and low mean and modal values not being always even of the same type, in forming a ratio we may be treating as comparable quantities which are, in some respects, incommensurable. While this latter consideration may be less weighty the former is of great importance.

Having definitely, we think, established our contention as to the skewness of the phagocytic populations, we ask—what will be the distribution of means of samples taken from such a population?

To answer this we should require perhaps 300 samples of 50 or a total count of 15,000 cells; we have not the hardihood to ask Dr Fleming or Dr Strangeways to undertake so heroic a count.

One of Dr Strangeways' counts, however, extended to 2000 cells, and he grouped his results in 80 batches of 25.

Adopting a somewhat coarse unit of grouping—0·12 bacilli—and using Sheppard's corrections, we obtained the following constants:

Mean* 1·691, Mode* 1·540, $\mu_2 = 7{\cdot}46104$, $\beta_1 = {\cdot}475566$, $\beta_2 = 3{\cdot}31849$.

$\kappa_2 = -{\cdot}50733$, Range* 1·0366 to 4·15397.

$$\text{Equation: } y = 12{\cdot}03429\left(1 + \frac{x}{4{\cdot}197737}\right)^{1{\cdot}93937} \times \left(1 - \frac{x}{21{\cdot}780512}\right)^{10{\cdot}0627}.$$

$P = {\cdot}92$. Skewness $= {\cdot}4597$. See Graph 16.

Now a sample of 80 means is too small to use as a conclusive argument, and besides, few or no pathologists would confine themselves to a phagocytic count of 25. Nevertheless, regarding the curve as an illustration, it suggests some interesting reflections.

The skewness is of course reduced, as we should expect on theoretical grounds, but still quite sensible and of the same order as in the case of the F. distributions. Supposing for a moment that the curve represents truly the distribution of the whole "population" of means, we see clearly how inappropriate would be the ordinary nomenclature for probable errors.

Thus the chance against a positive deviation as great as or greater than ·1691 is 3·6 to 1, while the chance against a negative deviation of ·0691 is 1·88 to 1.

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* These values are reduced to unit of observation, the equation is in terms of the statistical unit of grouping.

Translating these results into terms of opsonic indices, an index of ·9 is more likely to occur in random sampling than one of 1·1, or positive and negative deviations from unity do not occur with equal frequency (see Table VIII.).

TABLE VIII.

Some Ordinates and Areas from the Curve of Means.

Ordinate	Fraction of Total Area [Total Area = 1] bounded by this ordinate	Odds against such a deviation or a greater	Opsonic Index in terms of Mean
1·353 –	·14971	5·68 to 1	·8
1·5219 –	·34773	1·88 to 1	·9
1·8601 +	·73464	3·60 to 1	1·1
2·195 +	·92572	12·46 to 1	1·3

Concluding, we have shown: (1) that phagocytic counts have pronouncedly skew distributions; (2) that the means of small samples have likewise a skew distribution; (3) that although there is a sensible reduction in skewness when the modal value is raised by the employment of thick bacillary emulsions, there is no ground for thinking that the skewness can, under possible experimental conditions, be so reduced as to render testing on the basis of the Gaussian curve allowable; (4) the F. counts also differ from those of Dr Strangeways in the following respects: (*a*) they exhibit greater absolute but less relative variation, (*b*) the negative portion of the curve is increased, (*c*) they exhibit less uniformity in the value of P; (5) that the doubts expressed by Pearson as to the validity of employing "normal" tests for samples of skew material are experimentally proved to be well-founded.

A further examination of these phenomena and an attempt to solve approximately some of the problems arising therefrom will form the subject of a second memoir*.

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* We desire to express our sense of obligation to Professor Pearson, who has kindly allowed some of the more important calculations to be verified in his laboratory and has constantly helped us with advice and criticism.

A BIOMETRIC STUDY OF THE RED BLOOD CORPUSCLES OF THE COMMON TADPOLE (*RANA TEMPORARIA*), FROM THE MEASUREMENTS OF ERNEST WARREN, D.Sc.

BY KARL PEARSON, F.R.S.

(1) ON leaving for Natal in 1902 to take up his duties at the Government Museum, Pietermaritzburg, Dr Warren placed in my hands a quantity of material, the reductions of which will be published with many other data in a forthcoming memoir on homotyposis. Among this material were measurements on the red blood corpuscles of 71 tadpoles from a pond at Hendon. These measurements were, for several reasons, of peculiar interest to me. I had been working at the blood corpuscles of frogs, and had met with several difficulties in the investigation. One group of these difficulties turned on the problem of the "small sample," and the second set on the doubt which arose in my own mind as to whether the size of the cell in the individual of any species can be considered as independent of the bulk or age of the individual.

An interdependence of the two appeared to me not improbable on the basis of statistical material, a part only of which has been published. It is clear that any correlation of the kind indicated will influence to a greater or less extent the determination of homotyposis in the case of such cells. From a careful examination of the data themselves I was unable to detect signs of differentiation* in the *sizes* of the red blood corpuscles of any individual; nor were my biological friends able to give me evidence that such *size* differentiation actually existed for the tadpole, or indeed, if it existed at all, that it affected any *large* percentage of the red blood corpuscles of the frog or any other species. Differentiation was based in most cases on other than size characters.

In the absence of Dr Warren from England I do not feel justified, however, in making him responsible for any conclusions I may draw from his measurements.

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* A large amount of algebraical work was undertaken in the endeavour to break up the frequency distributions of the blood corpuscles into components, but no definite evidence of size heterogeneity could be obtained. The apparent bimodal nature of the characters in Tables A, D and F (pp. 412, 415, 417) emphasised in the homotyposis tables failed to allow of algebraic resolution, and is, I think, solely a result of the paucity of the sample.

The whole of the labour of measurement is due to him, and this is, perhaps, the most important part of the work. I have to thank my late colleague and assistant, Dr Alice Lee, and my present assistant, Miss Julia Bell, for most of the arithmetical work. My own task has been that of suggesting the nature of the statistical reductions to be made, and drawing from them possibly disputable conclusions. Foremost among these I take to be the point raised by Dr Warren himself in 1903, that in many cases an intimate relation exists between the size of the body and the size of the cell*. In the case of *Daphnia magna* the cell was a constituent part of the body length; in the present case we have to deal with a related but detached cell. I cannot avoid making the suggestion that the field for inquiry here is not only very wide, but exceedingly important.

The second difficulty that arises in the homotyposis of cellular characters is the practical difficulty of obtaining and measuring a sufficiently large sample of a cell population. The whole theory of "small" samples is only at present owing to the labours of von Bortkewitsch†, "Student"‡ and others, in course of development. But it is easy to see that the general effect of "small" sampling is to increase the apparent variability of the means of the sub-populations by terms depending on the error of random sampling and thus to make the variability of an array larger, and consequently the correlation, or in the special case the homotyposis, smaller than it should be as a result of "large" sampling. It is needful accordingly to bear in mind the double possibility (*a*) that cell size is correlated with the growth of the individual, and (*b*) that "small" sampling has considerable influence on these intercellular correlations.

(2) Dr Warren's material was collected at Hendon. The total length from tip of tail to head, and the body length from head to anus were measured. The end of the tail being removed, the maximum length and breadth of 25 corpuscles from a drop of blood from the wound were measured with an ocular micrometer. In the present paper, if the characters of rather more than 25 corpuscles were determined in a few cases by Dr Warren, I have dealt only with the first 25.

In the first place I shall consider the relation of cell length to body length, choosing this instead of total length as the length of the tail is much influenced by the changing state of development. Table A (see p. 412) gives the actual measurement of 25 blood corpuscles of 71 tadpoles, cell length against body length. In Diagram I. I have represented the same result graphically, taking the means of the lengths from the table below.

The correlation coefficient between cell and body length is $r = -\cdot 25$, and the correlation ratio—not very widely removed from it in value, and thus indicating approximately linear regression—is $\eta = \cdot 28$, with a probable error of about ·02. Thus there can be no doubt from this result that the size of the blood corpuscle of

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* *Biometrika*, Vol. II. p. 255.

† *Das Gesetz der kleinen Zahlen*, Leipzig, 1898.

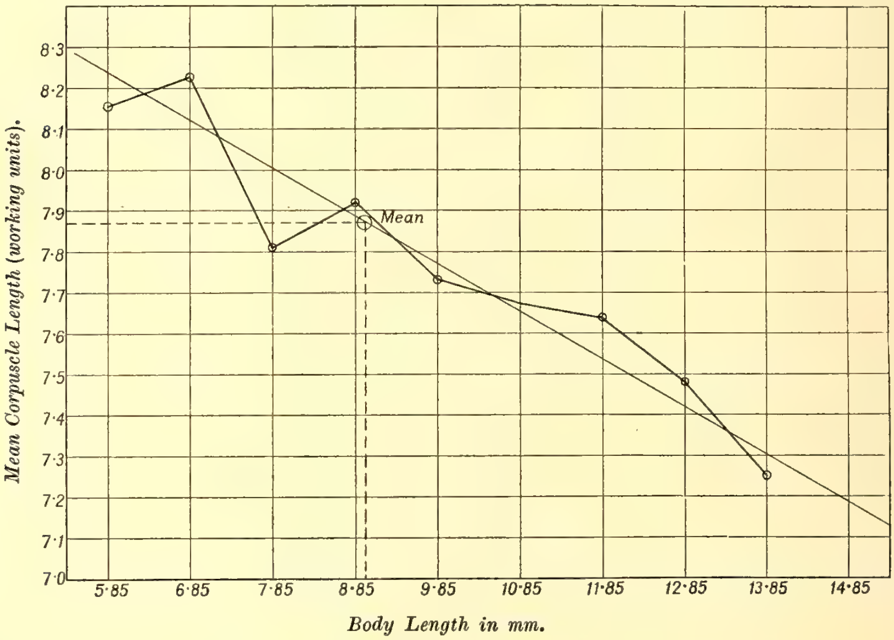
‡ *Biometrika*, Vol. VI. p. 1, and Vol. VI. p. 302.

TABLE I.

Mean Cell Length for each Body Length.

Body Lengths	Mean Cell Length	
Millimetres	Working units	Millimetres
5·35— 6·35	8·15	·0218
6·35— 7·35	8·22	·0220
7·35— 8·35	7·81	·0209
8·35— 9·35	7·91	·0212
9·35—10·35	7·73	·0207
10·35—11·35	7·67	·0206
11·35—12·35	7·64	·0205
12·35—13·35	7·48	·0200
13·35—14·35	7·25	·0194
All body Lengths	7·86	·0211

DIAGRAM I. Regression Line of Length of Blood Corpuscle on Body Length. *R. temporaria.*



the tadpole diminishes as it develops. It appears to me that this point wants testing in other species; it may well be that we are here dealing with a peculiar cellular change consequent on the development of the tadpoles, the larger of which were beginning to develop hind- and in a few cases fore-limbs. At the same time the decrease in size of blood corpuscles appears to have started with tadpoles so small that they showed no sign of limb development. The correlation – ·25 is in excellent agreement for the result obtained for tadpoles of *B. vulgaris,* namely – ·28; see Table IV. below. It will be obvious that if absolute lengths of the corpuscles were taken in either case, we should screen the true homotyposis owing to this change of corpuscle size with growth.

We can still further illustrate this point by finding the correlation between *total* length, that is 'body' + 'tail,' and the length of the corpuscle. We have $r = -\cdot 23$, showing a somewhat less, but still quite sensible, negative correlation, or the size of the corpuscle decreases with increasing total body length. I now proceeded to correlate the total length with the body length, and found $r = \cdot 93$. Now it is a noteworthy result of these numbers that $\cdot 93 \times -\cdot 25 = -\cdot 23$, or well within the limits of random sampling, we have:

Correlation of body length and cell length × correlation of total length and body length = correlation of total length and cell length.

That is to say, the partial correlation coefficient of total length on cell length for a constant body length is zero. We may therefore infer that the length of the tail has little or no influence on the length of the corpuscles, which are affected only by the growth of the body.

In Dr Warren's measurements, one ocular unit for the length or breadth of the corpuscle = ·00268 mm., and the mean length of 1775 blood corpuscles of tadpoles was 7·8554 working units = ·0211 mm. The late Professor Weldon measured for me, in 1901, 50 red blood corpuscles from each of 20 frogs. The method of procedure was somewhat different to that of Dr Warren, the frog being killed with chloroform and the blood taken from the heart; the frogs were from the neighbourhood of Oxford, whereas the tadpoles came from Hendon. Professor Weldon also drew the corpuscles, using a *camera lucida.* The mean cell length of these 1000 blood corpuscles of the adult frog was ·0256 mm. Comparing this value with that found for the tadpole at various stages as well as the mean value, it would seem highly probable that notwithstanding change of local race, the data point to the increase of size of the blood corpuscle of the frog with or after metamorphosis. Dr Warren also measured the length of the blood corpuscle in 25 corpuscles taken from each of 29 "toadpolls,"* or tadpoles of *Bufo vulgaris* taken from Kew lake. The mean value found was ·0212, which is in very close agreement with the mean result for the tadpoles from *R. temporaria.*

The following table sums up our results on corpuscle length.

TABLE II.

Length of Red Blood Corpuscles in mm.

Species	Number	Mean	Standard Deviation	Coefficient of Variation
R. temporaria (adult)	1000	·02560 ± ·00004	·00192 ± ·00003	7·50 ± ·11
R. temporaria (tadpole)	1775	·02105 ± ·00004	·00246 ± ·00003	11·69 ± ·13
B. vulgaris (toadpoll)	725	·02118 ± ·00006	·00251 ± ·00004	11·85 ± ·21

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[*] I should like to reintroduce the original of tadpole, i.e. toad-poll, as a convenient popular term for the tadpole of *B. vulgaris*; tadpole being reserved for *R. temporaria.*

We see that the two sets of tadpoles are again in close agreement as to variability, but whether we judge absolutely or relatively their corpuscles are in length more variable than those of the adult frog. It is possible that some amount of this difference of variability may be due to difference of treatment, Dr Warren taking his corpuscles from the truncated tail and Professor Weldon from the heart, but the bulk of the loss of variability is probably due to the fact that the tadpoles were at a variety of stages of growth, and the corpuscles, as we have seen, are also changing with this growth. Tables A, B and C (pp. 412—414) give respectively the correlation tables of body length and cell length, of total length and cell length, and of body length and total length for tadpoles of *R. temporaria*. The body and total lengths are in *mm.*, but the cell lengths in working units, each of which = ·00268 mm.

Table III. gives the biometric constants of the total and body lengths in mm. We see that notwithstanding the small numbers, the relative variabilities are in strikingly close agreement.

TABLE III.

Body and Total Lengths of R. temporaria and B. vulgaris Tadpoles.

Length		Number	Mean	Standard Deviation	Coefficient of Variation
Frog	Body	71	9·058	1·9443	21·46
	Total	69	26·125	5·5326	21·18
Toad	Body	29	8·966	1·7662	19·70
	Total	29	20·415	4·3103	21·11

The great range of variability here exhibited is due to the fact that we are dealing with different stages of growth, all clubbed together. One point, however, comes out from regarding the relative variabilities in Tables II. and III., i.e. that the influence of growth on variability of the body is nearly twice as great as it is on the variability of the cells.

(3) I now pass to the subject of breadth of the corpuscle. Correlating body length with the breadth of the corpuscle, we find from the data in Table D (p. 415):

$$r = -\cdot016 \pm \cdot016.$$

This, as in the case of length of corpuscle, is negative, but it is insensible, having regard to the probable error. This direct correlation is so small that it does not look as if it were solely due indirectly to the correlation between length and breadth of the corpuscle. The latter correlation, found from Table E (p. 416), is ·306, and if we find the partial correlation of breadth and body length for a constant corpuscle length, we have: $r = +\cdot062$, again very slight, but possibly significant, or for a constant length of body, the breadth of corpuscle would increase with size of body.

Let us next investigate how the volume of the corpuscle changes with increasing body length. A rough measure of this volume may be taken as $\gamma = b^2 l$, where b is the breadth and l the length of the corpuscle. If L equal the body length then very closely:

$$r_{\gamma L} = \frac{2v_b r_{bL} + v_l r_{lL}}{\sqrt{4v_b^2 + v_l^2 + 4v_b v_l r_{bl}}}.$$

Now the constants of the breadth frequency are

Mean = ·01530 mm. Standard Deviation = ·00208 mm.

Coefficient of Variation = $v_b = 13{\cdot}575$.

Hence remembering that $v_l = 11{\cdot}69$, $r_{bL} = -{\cdot}016$, $r_{lL} = -{\cdot}245$ and $r_{bl} = {\cdot}306$, we deduce:

$$r_{\gamma L} = -{\cdot}101.$$

We therefore conclude that the corpuscular volume decreases very slightly with the growth of the tadpole, but the more significant change is the negative correlation of corpuscular length, or the reduction of the corpuscular length with growth.

For comparison we have only the relatively few toadpolls, whose corpuscles were measured by Dr Warren. These give us the results below:

TABLE IV.

Comparison of Breadth in Corpuscles from Tadpoles of Toad and Frog.

	Number	Mean	Standard Deviation	v_b	r_{bl}	r_{bL}	r_{lL}
B. vulgaris ...	725	·01581	·00186	11·74	·520	– ·196	– ·277
R. temporaria...	1775	·01530	·00208	13·58	·306	– ·016	– ·245

It will be noted that the breadth is a more variable character than the length of the corpuscle in tadpoles. For toadpolls the variation is almost equal for length and breadth, but all the correlations are higher. In particular $r_{\gamma L} = -{\cdot}252$, being more than double the tadpole value. The smallness of the sample does not allow of our placing much stress on these differences, but in the essential feature that the blood corpuscle becomes smaller as the organism develops the toadpoll confirms the tadpole results completely.

For our present purposes it is desirable to follow out further the effect of increasing length on the breadth of the tadpole corpuscle. The value of the correlation ratio, η, was calculated from the length-breadth table (Table E, p. 416), and we found that while:

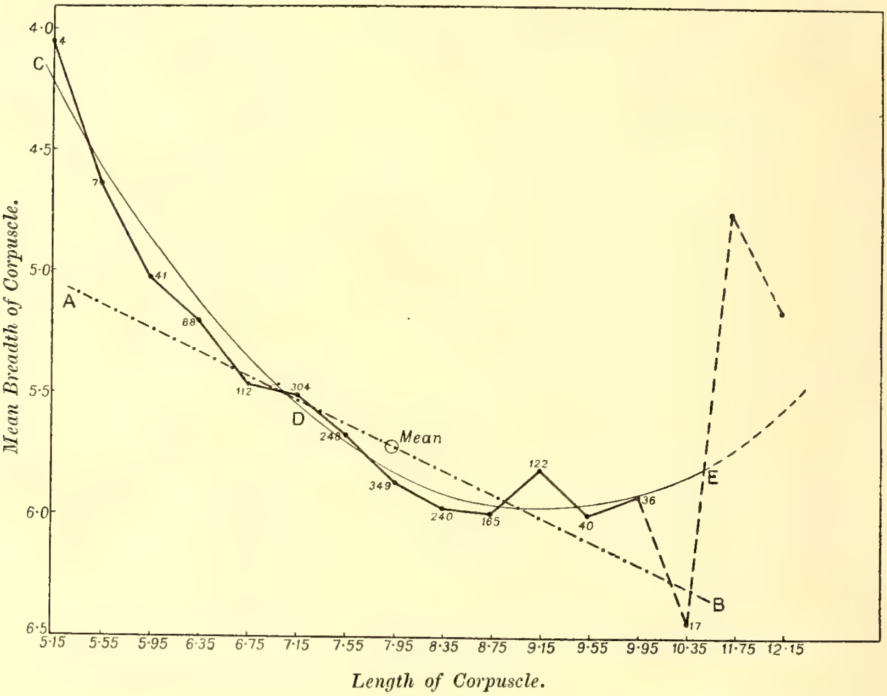
$$r = {\cdot}306 \pm {\cdot}015,$$

$$\eta = {\cdot}350.$$

There appeared thus to be a significant difference and on drawing the regression line, it was at once seen to be curved: see Diagram II.

The facts that the length of the corpuscle decreases with the growth of the tadpole, and further that the correlation between length and breadth is not very marked and is not linear, render it hard to obtain any character of the blood corpuscle free from growth changes.

DIAGRAM II. *R. temporaria* Tadpoles. Regression of Breadth on Length of Corpuscle.



The diagram shows the badness of fit of the regression line *AB*, and the improvement of fit when we adopt the regression parabola *CDE**, or:

$$\frac{y-\bar{y}}{\sigma_y} = r\frac{x-\bar{x}}{\sigma_x} \pm \sqrt{\frac{\eta^2 - r^2}{\beta_2 - \beta_1 - 1}}\left\{\left(\frac{x-\bar{x}}{\sigma_x}\right)^2 - \sqrt{\beta_1}\,\frac{x-\bar{x}}{\sigma_x} - 1\right\},$$

where β_1, β_2 are the usual biometric functions of the moments, σ_x and σ_y the standard deviations, $\bar{x}$, $\bar{y}$ the means of the lengths and breadths of the corpuscles.

In the present case the equation to this parabola referred to the mean as origin is:

$$Y = {\cdot}270X - {\cdot}109X^2 + {\cdot}094.$$

In judging of the fitness of the parabola no weight can be given to the means of the first and last few arrays, which contain very small numbers of corpuscles;

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* Pearson: "On the General Theory of Skew Correlation," *Drapers' Research Memoirs* (Dulau & Co.), p. 29.

the observed frequency is placed alongside each point. It may be doubted whether the ultimate decrease of breadth with increasing length is real and not solely due to the two abnormally narrow corpuscles of maximum length. Still there is some sign of a tendency to reduced breadth before these are reached.

(4) I had much hoped that the index of the blood corpuscle would be a character free from growth changes, but the previous section shows that in this respect it is not available. A direct investigation of the correlation of the body length of the tadpole and the index of its blood corpuscles (Table F) gives for the coefficient of correlation,

$$r = +\cdot 179 \pm \cdot 016.$$

Thus the index alters with the growth of the tadpole quite significantly, but not so intimately as in the case of the length of the corpuscle. The change is of course in the opposite direction since the index = breadth/length, and the small decrease in breadth is more than compensated by the greater decrease in length. The corpuscle tends to become rounder with the growth of the tadpole.

For comparative purposes, we find:

TABLE V.

Comparison of Corpuscle Indices for Tadpoles of Toad and Frog.

	Number	Mean	Standard Deviation	v_i	r_{iL}
B. vulgaris ...	725	·751	·0810	10·77	+ ·081
R. temporaria ...	1775	·732	·1047	14·31	+ ·179

It would thus appear that the corpuscle in the toadpoll is somewhat more brachycalic than in the tadpole, sensibly less variable and less modified by growth.

On plotting the means of the index arrays to the successive body lengths for tadpoles, the resultant regression line was a very irregular polygon, but showed distinct signs of a non-linear regression. Accordingly the correlation ratio η was found for the indices and body length, and gave the value $\eta = \cdot 348$, thus demonstrating that the index does not increase uniformly with the body length. It rises in fact quickly with body lengths from 5·6 to 7·8, and then remains nearly constant. I may remark that for a somewhat different series of tadpoles, the correlation ratio between index and *total* length, *not* body length, was found to be somewhat higher, i.e. $\eta = \cdot 405$. There is thus more relation between index of corpuscle and growth of the tadpole than is indicated by the correlation coefficient ·179. In the case of toadpoll's corpuscles, the regression is again not linear and the correlation ratio, η, is equal to ·273. To get rid of the lumpiness due to taking only 25 corpuscles from 71 tadpoles and 29 toadpolls, we need probably 50 to 100 corpuscles from four or five hundred individuals.

(5) Lastly an attempt was made to ascertain to what extent the blood corpuscles of an individual are characteristic of that individual. The difficulties here are undoubtedly considerable. At the outset of the investigation it was not anticipated that the red blood corpuscles would change in size with the growth of the individual, and it might well have been expected that if this should prove to be the case, the index would still be practically free from the growth factor. In the next place a good deal more inquiry is needed as to the influence of the locus of withdrawal and the treatment of the blood corpuscles, before very definite conclusions are drawn. 50 blood corpuscles drawn from the heart after obliterating the central nervous system in the case of Frog No. 3, when examined without any reagents, gave a value of the mean length = ·0262 mm. A second series of 50 blood corpuscles from the heart mixed with normal salt solution and exposed to vapour of chloroform for 20 to 30 seconds before measurement, gave mean length ·0260 mm. The mean length of 1000 corpuscles of adult frogs

$$= \cdot 0256 \pm \cdot 00004.$$

The error of a random sample of 50 would be about ·0002. It cannot therefore be asserted that the difference of the two samples of the same blood is due to treatment; it is just what might be expected in two random samples. Further the two sample means appear to be significantly different from the mean of the general population of corpuscles. Samples of at least 50 to 100 (and better the latter) ought to be taken, and uniformity observed in time of measurement after extraction and in actual treatment. The immense amount of labour involved is, however, a very serious consideration in such large sampling.

The problem of possible heterogeneity must also be borne in mind, but I think we may definitely assert that the blood corpuscles here dealt with certainly did not belong to any *two* well-marked classes, they failed to give real solutions in all attempts at analysis. It is of course conceivable, in fact not improbable, that the red corpuscles as a population are in various stages of growth, and till more is known as to the place and manner of production of these corpuscles it would be profitless to hazard any guess as to how this may affect the variability and individuality of the population. This may account in part for the relatively low values found for homotyposis in these free cells as compared with my unpublished data for homotyposis in fixed cells.

Emphasising these preliminary points, I will put together the results so far reached for the homotyposis or degree of resemblance of blood corpuscles in the same individual.

The probable errors are based on the number of corpuscles, not on the number of individuals or of pairs dealt with.

It will be obvious from this table that there is a sensible degree of individuality in the corpuscles of the same individual, the raw values of the coefficients are sufficient to demonstrate this. Further, by correcting for change in the blood

TABLE VI.

Homotyposis in the Red Blood Corpuscles of Frog and Toad.

	Character	Number of Individuals	Number of Pairs	Raw Value	Corrected Value	Table
R. temporaria, Adult ...	Length	20	49,000	·153 ± ·021	?[*]	G, p. 417
R. temporaria, Tadpoles	Index	71	42,600	·333 ± ·014	·405	H, p. 418
„ „	Length	61	36,600	·186 ± ·017	·206	I, p. 418
B. vulgaris, Toadpolls...	Index	29	17,400	·121 ± ·025	·134	J, p. 419

corpuscle with growth, we get somewhat higher values. If r be the raw correlation coefficient, η the correlation ratio between the character and stage of growth, R the corrected correlation and m the number of homotypes used, then I have shown that[†]:

$$R = \frac{r}{1-\eta^2} + \frac{\eta^2}{(m-1)(1-\eta^2)}.$$

From this formula are found the "corrected" values given in the last column of the table. It will be seen that while the changes are in the right direction, they do not raise the homotyposis to the value we might have anticipated from other published and unpublished homotypic results. We therefore conclude that while there is undoubtedly individuality of a homotypic character in the blood corpuscles of the species dealt with, there are very probably differentiating factors, not yet studied, which have not been allowed for when we merely correct the correlations on the basis of body growth. The suggestion that naturally arises is that the cell undergoes changes not only in relation to bodily growth, but probably in relation to its own life.

(6) *Conclusions.*

The object of the present paper will be fulfilled if it shows that:

(i) the size and form of the blood corpuscle is related to the life history of the organism to which it belongs;

(ii) there is a quite sensible individuality in the blood corpuscles of the same individual, if it be not so intense as the mean value which has been found for the homotyposis of purely homologous organs;

(iii) there is a wide field here for biometric inquiry, but it needs much labour and persistence, if the sample is to be 50—100 corpuscles in each of 400 to 500 individuals.

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[*] No body measurement was taken on these frogs, which were described merely as adult; thus no correction for size can be made.

[†] "On Homotyposis in Homologous, but differentiated Organs." *Proc. R. S.* Vol. 71, pp. 303—4 and footnote.

APPENDIX.

TABLE A.

R. temporaria, Tadpoles. Body Length and Length of Blood Corpuscles.

Body Length.

Length of Blood Corpuscles.	*5·35—5·85*	*5·85—6·35*	*6·35—6·85*	*6·85—7·35*	*7·35—7·85*	*7·85—8·35*	*8·35—8·85*	*8·85—9·35*	*9·35—9·85*	*9·85—10·35*	*10·35—10·85*	*10·85—11·35*	*11·35—11·85*	*11·85—12·35*	*12·35—12·85*	*12·85—13·35*	*13·35—13·85*	*13·85—14·35*	Totals
4·95— 5·15	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	1
5·15— 5·35	—	—	1	—	1	—	—	—	—	—	1	—	—	—	—	—	—	—	3
5·35— 5·55	—	—	—	—	1	—	—	—	—	—	—	—	1	—	—	—	—	—	2
5·55— 5·75	—	—	—	—	1	—	—	—	—	—	2	—	—	—	1	—	1	—	5
5·75— 5·95	—	—	—	—	3	—	1	1	2	—	4	—	—	—	—	—	—	—	11
5·95— 6·15	—	—	2	—	1	1	1	1	2	5	10	2	2	—	1	—	2	—	30
6·15— 6·35	—	1	1	1	2	1	2	7	2	4	4	2	2	1	3	—	1	2	36
6·35— 6·55	—	—	1	2	3	4	4	5	2	4	16	3	1	1	4	—	2	—	52
6·55— 6·75	2	—	3	1	2	1	4	9	3	3	—	1	2	1	3	—	—	1	36
6·75— 6·95	—	1	2	2	3	7	9	2	7	10	12	3	4	2	4	—	4	4	76
6·95— 7·15	1	4	7	8	8	9	14	9	11	9	17	13	2	1	3	—	3	3	122
7·15— 7·35	6	3	9	11	7	18	20	15	16	12	19	11	4	3	16	—	7	5	182
7·35— 7·55	4	3	7	17	10	11	15	10	8	9	15	9	8	1	5	—	1	1	134
7·55— 7·75	—	9	5	6	6	5	27	15	11	3	9	5	3	4	3	—	1	2	114
7·75— 7·95	5	10	13	20	10	18	22	12	21	10	11	11	3	3	10	—	1	2	182
7·95— 8·15	13	10	8	17	5	12	24	15	8	9	18	11	5	5	5	—	1	1	167
8·15— 8·35	5	5	10	21	10	11	17	18	12	10	16	10	1	2	13	—	—	1	162
8·35— 8·55	3	6	6	10	2	6	12	7	14	1	4	5	1	—	1	—	—	—	78
8·55— 8·75	3	5	6	6	5	4	5	3	6	4	12	5	2	—	—	—	—	—	66
8·75— 8·95	4	7	9	20	4	5	12	8	11	3	8	2	3	—	1	—	1	1	99
8·95— 9·15	—	3	11	12	10	3	9	2	4	3	5	2	2	1	1	—	—	1	69
9·15— 9·35	2	4	7	9	1	2	7	6	4	—	5	2	4	—	—	—	—	—	53
9·35— 9·55	1	1	6	1	2	2	5	—	1	1	3	—	—	—	—	—	—	—	23
9·55— 9·75	—	1	3	3	—	2	2	1	1	—	2	2	—	—	—	—	—	—	17
9·75— 9·95	—	2	3	7	—	1	3	2	1	—	3	—	—	—	—	—	—	—	22
9·95—10·15	1	—	2	1	2	2	2	1	—	—	2	—	—	—	—	—	—	1	14
10·15—10·35	—	—	1	—	1	—	5	—	3	—	1	—	—	—	1	—	—	—	12
10·35—10·55	—	—	1	—	—	—	3	1	—	—	—	—	—	—	—	—	—	—	5
10·55—10·75	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
10·75—10·95	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0
10·95—11·15	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	1
Totals	50	75	125	175	100	125	225	150	150	100	200	100	50	25	75	0	25	25	1775

TABLE B.

R. temporaria, Tadpoles. *Total Length (with tail) and Length of Corpuscles.*

Body Length (with tail).

Length of Corpuscles.	*16·35—17·35*	*17·35—18·35*	*18·35—19·35*	*19·35—20·35*	*20·35—21·35*	*21·35—22·35*	*22·35—23·35*	*23·35—24·35*	*24·35—25·35*	*25·35—26·35*	*26·35—27·35*	*27·35—28·35*	*28·35—29·35*	*29·35—30·35*	*30·35—31·35*	*31·35—32·35*	*32·35—33·35*	*33·35—34·35*	*34·35—35·35*	*35·35—36·35*	*36·35—37·35*	*37·35—38·35*	*38·35—39·35*	*39·35—40·35*	*40·35—41·35*	*41·35—42·35*	*42·35—43·35*	Totals
4·95— 5·15	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
5·15— 5·35	—	—	—	—	1	1	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	3
5·35— 5·55	—	—	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2
5·55— 5·75	—	—	—	—	—	1	—	—	—	—	1	—	1	—	—	—	—	—	—	2	—	—	—	—	—	—	—	5
5·75— 5·95	—	—	—	2	—	1	—	1	—	—	2	—	2	2	—	—	—	—	—	—	—	—	—	—	—	—	—	10
5·95— 6·15	—	1	—	2	—	1	—	1	1	—	5	3	1	3	6	1	1	—	—	3	—	—	—	—	—	—	—	29
6·15— 6·35	—	—	1	—	2	1	—	2	2	2	2	6	4	2	2	3	—	—	—	4	—	1	—	—	—	—	2	36
6·35— 6·55	—	—	1	3	—	1	1	6	2	2	1	5	9	5	3	2	2	1	—	5	—	1	1	—	—	—	—	51
6·55— 6·75	2	2	—	2	2	1	1	1	2	6	—	8	—	—	3	1	—	—	—	2	—	1	1	—	—	—	1	36
6·75— 6·95	—	1	1	4	1	1	2	7	3	5	1	6	6	1	11	2	2	3	—	7	—	2	1	—	—	—	4	71
6·95— 7·15	—	2	4	8	7	5	3	11	6	10	4	15	9	4	8	6	4	3	—	5	—	1	1	—	—	—	3	119
7·15— 7·35	4	4	3	10	9	5	2	17	8	19	4	20	9	4	12	7	3	2	—	16	—	3	7	—	—	—	5	173
7·35— 7·55	2	5	3	13	7	9	4	17	7	7	1	17	6	10	9	2	—	6	—	4	—	1	2	—	—	—	1	133
7·55— 7·75	2	1	6	8	5	3	—	12	14	13	4	18	3	6	2	3	1	1	—	2	—	4	2	—	—	—	2	112
7·75— 7·95	5	8	6	6	19	11	4	20	6	12	4	24	17	3	4	8	2	1	—	10	—	3	1	—	—	—	2	176
7·95— 8·15	11	8	5	13	12	5	2	16	5	15	7	16	9	8	6	7	2	4	—	6	—	5	—	—	—	—	1	163
8·15— 8·35	3	6	5	10	15	4	1	21	4	9	8	24	12	7	4	5	2	1	—	6	—	2	7	—	—	—	1	157
8·35— 8·55	6	2	4	2	6	5	1	7	3	8	2	17	5	2	2	1	2	—	—	1	—	—	—	—	—	—	—	76
8·55— 8·75	3	4	2	9	2	4	—	7	3	3	2	6	12	4	1	—	2	1	—	—	—	—	—	—	—	—	—	65
8·75— 8·95	7	4	4	12	12	5	1	7	5	9	—	16	5	2	1	—	1	2	—	1	—	—	1	—	—	—	1	96
8·95— 9·15	1	—	7	8	12	2	1	10	3	5	—	6	2	4	1	1	1	—	—	1	—	1	—	—	—	—	1	67
9·15— 9·35	2	—	8	7	6	3	—	6	—	5	—	8	3	3	—	1	—	—	—	—	—	—	—	—	—	—	—	52
9·35— 9·55	—	2	4	2	1	1	—	3	—	5	—	1	4	—	—	—	—	—	—	—	—	—	—	—	—	—	—	23
9·55— 9·75	—	—	2	2	2	1	1	—	—	2	—	2	2	2	—	—	—	—	—	—	—	—	—	—	—	—	—	16
9·75— 9·95	1	—	4	—	3	4	—	—	—	3	—	3	1	2	—	—	—	—	—	—	—	—	—	—	—	—	—	21
9·95—10·15	1	—	2	—	1	—	1	2	—	3	—	—	1	1	—	—	—	—	—	—	—	—	—	—	—	—	1	13
10·15—10·35	—	—	1	—	—	—	—	1	—	5	—	3	1	—	—	—	—	—	—	—	—	—	1	—	—	—	—	12
10·35—10·55	—	—	1	—	—	—	—	—	1	2	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	5
10·55—10·75	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
10·75—10·95	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0
10·95—11·15	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
Totals	50	50	75	125	125	75	25	175	75	150	50	225	125	75	75	50	25	25	0	75	0	25	25	0	0	0	25	1725

TABLE C.

R. temporaria, Tadpoles. Body Length with and without tail.

Body Length without tail.

Body Length with tail.

	5·35—5·85	5·85—6·35	6·35—6·85	6·85—7·35	7·35—7·85	7·85—8·35	8·35—8·85	8·85—9·35	9·35—9·85	9·85—10·35	10·35—10·85	10·85—11·35	11·35—11·85	11·85—12·35	12·35—12·85	12·85—13·35	13·35—13·85	13·85—14·35	Totals
16·35—17·35	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2
17·35—18·35	1	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2
18·35—19·35	—	1	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	3
19·35—20·35	—	1	1	1	1	—	—	—	—	—	—	—	1	—	—	—	—	—	5
20·35—21·35	—	—	1	4	—	—	—	—	—	—	—	—	—	—	—	—	—	—	5
21·35—22·35	—	—	—	2	1	—	—	—	—	—	—	—	—	—	—	—	—	—	3
22·35—23·35	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	1
23·35—24·35	—	—	—	—	2	3	2	—	—	—	—	—	—	—	—	—	—	—	7
24·35—25·35	—	—	—	—	—	—	3	—	—	—	—	—	—	—	—	—	—	—	3
25·35—26·35	—	—	—	—	—	—	4	2	—	—	—	—	—	—	—	—	—	—	6
26·35—27·35	—	—	—	—	—	—	—	1	—	—	1	—	—	—	—	—	—	—	2
27·35—28·35	—	—	—	—	—	—	—	3	4	2	—	—	—	—	—	—	—	—	9
28·35—29·35	—	—	—	—	—	—	—	—	1	1	2	1	—	—	—	—	—	—	5
29·35—30·35	—	—	—	—	—	—	—	—	—	—	2	1	—	—	—	—	—	—	3
30·35—31·35	—	—	—	—	—	—	—	—	—	1	1	—	1	—	—	—	—	—	3
31·35—32·35	—	—	—	—	—	—	—	—	—	—	1	1	—	—	—	—	—	—	2
32·35—33·35	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	1
33·35—34·35	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	1
34·35—35·35	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0
35·35—36·35	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	—	1	—	3
36·35—37·35	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0
37·35—38·35	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	1
38·35—39·35	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	1
39·35—40·35	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0
40·35—41·35	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0
41·35—42·35	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0
42·35—43·35	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1
Totals	2	3	5	7	4	4	9	6	5	4	8	4	2	1	3	0	1	1	69

TABLE D.

R. temporaria, Tadpoles. Body Length and Breadth of Corpuscles.

Body Length.

Breadth of Blood Corpuscles.	*5·35—5·85*	*5·85—6·35*	*6·35—6·85*	*6·85—7·35*	*7·35—7·85*	*7·85—8·35*	*8·35—8·85*	*8·85—9·35*	*9·35—9·85*	*9·85—10·35*	*10·35—10·85*	*10·85—11·35*	*11·35—11·85*	*11·85—12·35*	*12·35—12·85*	*12·85—13·35*	*13·35—13·85*	*13·85—14·35*	Totals
2·95—3·15	—	—	1	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	2
3·15—3·35	—	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2
3·35—3·55	—	—	2	—	—	—	—	—	—	1	1	—	—	—	—	—	—	—	4
3·55—3·75	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
3·75—3·95	—	—	2	1	—	—	—	—	—	—	1	—	1	—	—	—	—	—	5
3·95—4·15	—	—	3	1	—	1	2	1	1	—	4	—	2	—	—	—	—	—	15
4·15—4·35	—	—	8	5	3	4	4	1	4	3	8	—	7	—	2	—	4	—	53
4·35—4·55	1	2	4	1	2	—	—	1	3	—	5	—	5	—	—	—	1	—	25
4·55—4·75	1	3	8	7	1	5	4	3	6	2	5	3	3	—	4	—	—	3	58
4·75—4·95	5	—	9	8	3	13	14	7	15	9	12	7	5	—	4	—	1	1	113
4·95—5·15	6	5	15	16	5	9	7	5	8	5	10	6	2	2	4	—	5	2	112
5·15—5·35	9	7	16	36	14	19	13	15	27	13	14	7	5	6	11	—	2	4	218
5·35—5·55	7	7	8	24	11	11	19	18	9	12	19	12	7	3	8	—	3	7	185
5·55—5·75	8	7	7	13	5	9	22	10	10	12	13	14	2	2	8	—	4	2	148
5·75—5·95	1	8	8	15	8	8	27	15	23	7	18	6	2	4	4	—	3	3	160
5·95—6·15	1	7	9	16	11	9	17	14	10	5	25	11	4	2	7	—	1	2	151
6·15—6·35	7	7	9	14	9	12	30	25	16	11	29	9	4	2	9	—	1	—	194
6·35—6·55	3	4	6	3	4	8	12	10	7	3	14	7	—	3	6	—	—	1	91
6·55—6·75	1	1	1	3	7	6	12	7	3	5	11	4	—	—	3	—	—	—	64
6·75—6·95	—	7	4	5	6	3	15	10	6	6	4	4	1	—	4	—	—	—	75
6·95—7·15	—	3	—	5	4	1	10	3	2	2	3	6	—	1	1	—	—	—	41
7·15—7·35	—	5	1	2	4	5	7	1	—	1	3	4	—	—	—	—	—	—	33
7·35—7·55	—	1	1	—	—	—	3	1	—	1	1	—	—	—	—	—	—	—	8
7·55—7·75	—	—	—	—	—	1	3	1	—	1	—	—	—	—	—	—	—	—	6
7·75—7·95	—	1	—	—	—	1	—	1	—	—	—	—	—	—	—	—	—	—	3
7·95—8·15	—	—	—	—	1	—	—	1	—	—	—	—	—	—	—	—	—	—	2
8·15—8·35	—	—	—	—	1	—	1	—	—	—	—	—	—	—	—	—	—	—	2
8·35—8·55	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0
8·55—8·75	—	—	—	—	1	—	1	—	—	—	—	—	—	—	—	—	—	—	2
8·75—8·95	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	1
8·95—9·15	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	1
Totals	50	75	125	175	100	125	225	150	150	100	200	100	50	25	75	0	25	25	1775

TABLE E.

R. temporaria, Tadpoles. Length and Breadth of Corpuscles.

Length of Corpuscle.

Breadth of Corpuscle.

	4·95—5·15	5·15—5·35	5·35—5·55	5·55—5·75	5·75—5·95	5·95—6·15	6·15—6·35	6·35—6·55	6·55—6·75	6·75—6·95	6·95—7·15	7·15—7·35	7·35—7·55	7·55—7·75	7·75—7·95	7·95—8·15	8·15—8·35	8·35—8·55	8·55—8·75	8·75—8·95	8·95—9·15	9·15—9·35	9·35—9·55	9·55—9·75	9·75—9·95	9·95—10·15	10·15—10·35	10·35—10·55	10·55—10·75	10·75—10·95	10·95—11·15	Totals
2·95—3·15	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	2
3·15—3·35	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	2
3·35—3·55	—	1	—	—	—	—	—	—	—	—	—	—	—	—	1	—	1	—	—	—	—	1	—	—	—	—	—	—	—	—	—	4
3·55—3·75	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	1
3·75—3·95	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	1	2	—	—	—	1	—	—	—	—	—	—	—	—	—	—	5
3·95—4·15	1	—	—	—	—	—	1	—	—	—	1	2	—	2	1	1	—	—	1	1	1	—	1	—	2	—	—	—	—	—	—	15
4·15—4·35	—	2	—	2	1	2	1	7	—	1	5	4	6	2	—	2	3	—	2	4	5	2	—	—	1	1	—	—	—	—	—	53
4·35—4·55	—	—	—	2	—	1	1	1	—	1	2	—	5	3	1	2	2	1	—	—	1	—	1	1	—	—	—	—	—	—	—	25
4·55—4·75	—	—	1	—	1	4	6	1	2	4	7	5	4	1	7	2	1	1	1	5	2	1	—	—	1	—	1	—	—	—	—	58
4·75—4·95	—	—	—	—	2	6	5	6	7	5	17	14	6	6	5	9	6	4	3	1	5	2	—	2	—	—	—	1	1	—	—	113
4·95—5·15	—	—	1	1	1	3	10	2	3	10	7	13	10	5	10	6	9	3	3	4	3	4	—	2	—	1	—	—	—	—	1	112
5·15—5·35	—	—	—	—	3	6	5	10	7	8	25	27	19	15	26	19	10	10	1	10	6	6	2	—	3	—	—	—	—	—	—	218
5·35—5·55	—	—	—	—	1	4	4	5	6	15	14	21	10	15	22	10	21	3	6	12	4	7	—	1	1	1	1	1	—	—	—	185
5·55—5·75	—	—	—	—	1	1	1	4	5	9	10	14	17	5	17	15	15	8	5	7	4	4	2	1	1	1	1	—	—	—	—	148
5·75—5·95	—	—	—	—	1	1	1	9	4	8	12	24	15	16	16	11	8	6	11	5	7	2	1	2	—	—	—	—	—	—	—	160
5·95—6·15	—	—	—	—	—	1	—	2	1	6	12	28	12	8	20	15	14	7	2	3	6	4	3	1	2	2	2	—	—	—	—	151
6·15—6·35	—	—	—	—	—	—	—	3	—	4	3	20	15	19	28	25	21	12	6	13	6	3	3	3	2	5	2	1	—	—	—	194
6·35—6·55	—	—	—	—	—	—	1	1	1	3	1	3	1	6	12	14	15	4	4	13	2	3	3	—	3	—	1	—	—	—	—	91
6·55—6·75	—	—	—	—	—	—	—	—	—	2	4	3	4	—	8	16	9	4	5	2	2	1	1	—	2	1	—	—	—	—	—	64
6·75—6·95	—	—	—	—	—	—	—	—	—	—	1	3	7	4	5	8	9	5	8	9	6	5	1	2	1	—	1	—	—	—	—	75
6·95—7·15	—	—	—	—	—	—	—	—	—	—	—	—	2	3	1	2	11	3	5	4	4	3	2	—	—	—	1	—	—	—	—	41
7·15—7·35	—	—	—	—	—	—	—	—	—	—	—	—	1	3	2	6	5	3	2	3	2	2	1	—	2	—	—	1	—	—	—	33
7·35—7·55	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	1	—	—	—	3	—	2	—	1	—	—	—	—	—	—	—	8
7·55—7·75	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	2	—	—	—	—	1	—	—	1	—	1	—	—	—	6
7·75—7·95	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	1	1	—	—	—	—	—	—	—	—	—	—	—	—	3
7·95—8·15	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	2
8·15—8·35	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	1	—	—	—	—	2
8·35—8·55	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0
8·55—8·75	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	1	—	—	—	—	—	2
8·75—8·95	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	1
8·95—9·15	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	1
Totals	1	3	2	5	11	30	36	52	36	76	122	182	134	114	182	167	162	78	66	99	69	53	23	17	22	14	12	5	1	0	1	1775

TABLE F.

R. temporaria, Tadpoles. Body Length and Indices.

Body Length.

Indices. (Breadth/Length.)	5·35—5·85	5·85—6·35	6·35—6·85	6·85—7·35	7·35—7·85	7·85—8·35	8·35—8·85	8·85—9·35	9·35—9·85	9·85—10·35	10·35—10·85	10·85—11·35	11·35—11·85	11·85—12·35	12·35—12·85	12·85—13·35	13·35—13·85	13·85—14·35	Totals
·3355— ·3755	—	—	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	3
·3755— ·4155	—	—	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2
·4155— ·4555	—	—	5	—	—	1	—	—	—	1	1	—	1	—	—	—	—	—	9
·4555— ·4955	—	—	8	5	1	2	—	—	3	1	3	1	5	—	—	—	—	—	29
·4955— ·5355	—	—	10	3	—	—	4	—	2	1	2	1	3	—	1	—	—	2	29
·5355— ·5755	1	2	11	8	2	3	4	2	6	—	5	1	5	—	—	—	—	—	50
·5755— ·6155	5	8	10	22	4	13	13	9	7	4	12	10	5	1	2	—	2	—	127
·6155— ·6555	13	4	13	21	6	10	18	5	13	2	15	9	3	—	4	—	—	1	137
·6555— ·6955	10	12	15	42	11	14	28	20	27	11	20	7	5	4	9	—	2	4	241
·6955— ·7355	10	9	11	27	16	18	31	12	29	12	18	9	2	3	8	—	6	3	224
·7355— ·7755	6	19	13	25	14	20	31	30	34	25	23	7	4	5	19	—	7	9	291
·7755— ·8155	3	12	10	12	15	19	31	24	16	17	34	18	7	7	17	—	5	4	251
·8155— ·8555	2	5	11	5	15	17	33	30	9	16	31	16	3	4	7	—	3	—	207
·8555— ·8955	—	2	2	2	3	5	12	10	3	4	22	9	6	—	4	—	—	2	86
·8955— ·9355	—	2	2	—	8	1	11	4	—	3	11	8	1	1	2	—	—	—	54
·9355— ·9755	—	—	—	2	3	2	8	3	—	2	3	2	—	—	2	—	—	—	27
·9755—1·0155	—	—	—	—	1	—	1	1	1	—	—	1	—	—	—	—	—	—	5
1·0155—1·0555	—	—	—	—	1	—	—	—	—	1	—	1	—	—	—	—	—	—	3
Totals	50	75	125	175	100	125	225	150	150	100	200	100	50	25	75	0	25	25	1775

TABLE G.

Homotyposis in Length of Red Blood Corpuscles in R. temporaria (Adult Frogs).

Length of First Corpuscle.

Length of Second Corpuscle.	39·4—38·5	38·4—37·5	37·4—36·5	36·4—35·5	35·4—34·5	34·4—33·5	33·4—32·5	32·4—31·5	31·4—30·5	30·4—29·5	29·4—28·5	28·4—27·5	27·4—26·5	26·4—25·5	25·4—24·5	24·4—23·5	Totals
39·4—38·5	—	1	7	—	2	19	17	18	16	13	3	2	—	—	—	—	98
38·4—37·5	1	4	11	14	51	73	52	67	44	27	34	11	—	2	1	—	392
37·4—36·5	7	11	36	36	108	201	153	222	157	127	66	28	12	3	9	—	1176
36·4—35·5	—	14	36	122	136	289	260	358	219	145	144	41	22	6	15	6	1813
35·4—34·5	2	51	108	136	606	737	641	795	425	341	268	99	20	14	16	4	4263
34·4—33·5	19	73	201	289	737	1142	1035	1292	853	586	450	142	43	22	18	7	6909
33·4—32·5	17	52	153	260	641	1035	990	1245	839	618	531	208	84	39	39	11	6762
32·4—31·5	18	67	222	358	795	1292	1245	1568	1254	837	677	300	95	38	46	8	8820
31·4—30·5	16	44	157	219	425	853	839	1254	1098	706	595	298	92	36	30	2	6664
30·4—29·5	13	27	127	145	341	586	618	837	706	546	452	221	91	48	43	1	4802
29·4—28·5	3	34	66	144	268	450	531	677	595	452	470	222	98	47	51	8	4116
28·4—27·5	2	11	28	41	99	142	208	300	298	221	222	124	64	20	33	—	1813
27·4—26·5	—	—	12	22	20	43	84	95	92	91	98	64	28	12	24	1	686
26·4—25·5	—	2	3	6	14	22	39	38	36	48	47	20	12	2	5	—	294
25·4—24·5	—	1	9	15	16	18	39	46	30	43	51	33	24	5	12	1	343
24·4—23·5	—	—	—	6	4	7	11	8	2	1	8	—	1	—	1	—	49
Totals	98	392	1176	1813	4263	6909	6762	8820	6664	4802	4116	1813	686	294	343	49	49000

TABLE H.

Homotyposis in Index of Red Blood Corpuscles of Tadpoles, R. temporaria.

Index of First Corpuscle.

Index of Second Corpuscle.	*34—*	*38—*	*42—*	*46—*	*50—*	*54—*	*58—*	*62—*	*66—*	*70—*	*74—*	*78—*	*82—*	*86—*	*90—*	*94—*	*98—*	*102—*	Totals
34—	2	2	8	6	15	9	8	14	4	2	2	—	—	—	—	—	—	—	72
38—	2	—	3	5	7	3	6	9	5	4	2	2	—	—	—	—	—	—	48
42—	8	3	8	18	29	25	30	34	21	11	15	9	4	1	—	—	—	—	216
46—	6	5	18	42	47	68	92	74	86	55	50	55	23	20	6	—	1	—	648
50—	15	7	29	47	46	61	83	88	93	49	68	42	20	11	9	4	—	—	672
54—	9	3	25	68	61	82	151	148	195	130	144	113	59	19	10	3	4	—	1224
58—	8	6	30	92	83	151	308	346	510	401	413	314	185	67	36	20	3	3	2976
62—	14	9	34	74	88	148	346	366	520	467	439	366	255	102	67	29	8	2	3384
66—	4	5	21	86	93	195	510	520	940	804	1015	718	486	189	121	59	14	4	5784
70—	2	4	11	55	49	130	401	467	804	688	895	730	548	198	143	78	18	11	5232
74—	2	2	15	50	68	144	413	489	1015	895	1266	1082	788	339	180	103	24	13	6888
78—	—	2	9	55	42	113	314	366	718	730	1082	972	906	400	226	110	34	17	6096
82—	—	—	4	23	20	59	185	255	486	548	788	906	890	403	286	128	25	10	5016
86—	—	—	1	20	11	19	67	102	189	198	339	400	403	204	125	47	7	4	2136
90—	—	—	—	6	9	10	36	67	121	143	180	226	286	125	82	46	3	4	1344
94—	—	—	—	—	4	3	20	29	59	78	103	110	128	47	46	14	3	4	648
98—	—	—	—	1	—	4	3	8	14	18	24	34	25	7	3	3	—	—	144
102—	—	—	—	—	—	—	3	2	4	11	13	17	10	4	4	4	—	—	72
Totals	72	48	216	648	672	1224	2976	3384	5784	5232	6888	6096	5016	2136	1344	648	144	72	42600

In this table "34—" signifies all corpuscles, the index of which falls into the range 34 up to, but not including, 38 and so on.

TABLE I.

Homotyposis in Length of Red Blood Corpuscles of Tadpoles, R. temporaria.

Length of First Corpuscle.

Length of Second Corpuscle.	*50—*	*55—*	*60—*	*65—*	*70—*	*75—*	*80—*	*85—*	*90—*	*95—*	*100—*	*105—*	Totals
50—	—	4	3	7	21	20	10	3	4	—	—	—	72
55—	4	6	26	33	61	56	50	29	18	2	3	—	288
60—	3	26	150	195	418	295	344	178	99	25	19	—	1752
65—	7	33	195	286	699	430	494	245	122	41	35	5	2592
70—	21	61	418	699	1986	1629	1700	837	502	124	100	11	8088
75—	20	56	295	430	1629	1500	1596	742	495	129	62	6	6960
80—	10	50	344	494	1700	1596	1836	964	674	212	143	17	8040
85—	3	29	178	245	837	742	964	558	411	128	75	6	4176
90—	4	18	99	122	502	495	674	411	384	152	104	11	2976
95—	—	2	25	41	124	129	212	128	152	56	59	8	936
100—	—	3	19	35	100	62	143	75	104	59	40	8	648
105—	—	—	—	5	11	6	17	6	11	8	8	—	72
Totals	72	288	1752	2592	8088	6960	8040	4176	2976	936	648	72	36600

In this table "50—" signifies all corpuscles the lengths of which were 50 or any value up to, but not including, 55 working units. It differs from Table H in that only 61 individuals were included, 10 showing more or less signs of leg development were excluded by the tabulator, but the corpuscles of these 10 do not seem on examination to be markedly different from those of the remainder.

TABLE J.

Homotyposis in Index of the Red Blood Corpuscles of Toadpolls (B. vulgaris).

Index of First Corpuscle.

Index of Second Corpuscle.	*46—*	*50—*	*54—*	*58—*	*62—*	*66—*	*70—*	*74—*	*78—*	*82—*	*86—*	*90—*	*94—*	*98—*	*102—*	*106—*	Totals
46—	—	4	5	5	6	5	8	5	5	1	2	1	1	—	—	—	48
50—	4	4	10	11	14	17	25	25	20	3	6	3	2	—	—	—	144
54—	5	10	10	15	27	32	42	37	35	22	20	3	4	1	1	—	264
58—	5	11	15	10	22	42	69	67	49	18	16	6	3	2	1	—	336
62—	6	14	27	22	72	135	164	206	133	64	50	8	8	2	1	—	912
66—	5	17	32	42	135	260	364	462	307	185	107	28	12	6	5	1	1968
70—	8	25	42	69	164	364	554	794	558	252	166	55	21	11	8	5	3096
74—	5	25	37	67	206	462	794	968	798	386	212	74	19	14	9	4	4080
78—	5	20	35	49	133	307	558	798	678	379	220	63	25	5	9	4	3288
82—	1	3	22	18	64	185	252	386	379	222	111	42	9	3	4	3	1704
86—	2	6	20	16	50	107	166	212	220	111	62	19	9	1	4	3	1008
90—	1	3	3	6	8	28	55	74	63	42	19	2	3	1	2	2	312
94—	1	2	4	3	8	12	21	19	25	9	9	3	—	1	2	1	120
98—	—	—	1	2	2	6	11	14	5	3	1	1	1	—	1	—	48
102—	—	—	1	1	1	5	8	9	9	4	4	2	2	1	—	1	48
106—	—	—	—	—	—	1	5	4	4	3	3	2	1	—	1	—	24
Totals	48	144	264	336	912	1968	3096	4080	3288	1704	1008	312	120	48	48	24	17400

In this table "46—" signifies the group of corpuscles with 46 for index, and any value up to but not including 50, and so on.

DATA ON VARIATION IN THE COMB OF THE DOMESTIC FOWL*.

By RAYMOND PEARL AND MAUD DEWITT PEARL.

1. MUCH of the evidence adduced in support of Mendel's law as a general method of inheritance has been derived from breeding experiments with the domestic fowl. The work of Bateson, Hurst, and Davenport has served to make it a classical object of research in this field. One of the most obvious of the "unit characters" of poultry is the form of the comb. All students of inheritance in this group have included the study of the comb in their work. The behaviour of the various comb types in inheritance is frequently cited as a well-nigh perfect example of typical allelomorphism. The different comb types—single, pea, rose, etc.—are commonly said not to blend in cross-breeding, but instead to be inherited in a strictly alternative manner and in accordance with Mendel's law.

In spite of the extensive use of comb form in poultry as a character in the study of inheritance there has been, so far as we are aware, no particular study ever made of the degree and character of variation within each of the several known types of comb. About a year ago an opportunity was afforded one of us to carry on extensive breeding experiments with poultry. The plans made for the prosecution of such experiments included the investigation of the inheritance of comb characteristics. It was felt to be highly desirable in connection with this work to gain some sort of idea of the degree and manner in which there was variation *within* each of the several comb types. Such questions as the following suggest themselves: How far from the normal in any direction may the single comb, for example, be expected to depart in pure bred birds? What degree of variation, biometrically considered, do the various comb characters exhibit? The work of Weldon on peas† and on Lychnis‡ has demonstrated the importance of such studies in relation to the analytical investigation of Mendelian phenomena. All studies of this kind take their point of departure in an attempt to analyze a broad Mendelian category. In Mendelian discussion "single comb" is a "unit character." All "single" combs are put together in one category, all "pea" combs in another. But nothing is more certain than that all single combs are not alike in respect to any feature whatsoever, even including their "singleness." How much and in what ways do they vary? Do the variants *within* the category mendelize? Are all variants exactly equivalent in crossing with other categories? An answer to these and other easily suggested questions could not fail, it seems to us, to throw light on the problem of the constitution and physiology of the gametic determinants of "unit characters," assuming that such determinants exist.

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* Papers from the Biological Laboratory of the Maine Agricultural Experiment Station. Orono, Maine, U.S.A., No. 8.

† *Biometrika*, Vol. I. pp. 228—254.

‡ *Ibid.* Vol. II. pp. 44—55.

In this paper we have endeavoured to give a clear and, so far as possible, quantitative *description* of the nature and amount of variation normally occurring in a homogeneous pure bred strain of Barred Plymouth Rock hens in respect to the form and size of the comb. The aim of the paper is purely descriptive, and it is regarded by the authors as preliminary to the analytical investigation of comb inheritance.

2. Up to this time we have only been able to collect anything approaching a statistically adequate amount of material regarding comb variation for single combs alone. There is a certain fitness in taking up this comb at the start, because it is the primitive form*. In the course of the routine work of the laboratory, there came an opportunity in connection with certain autopsy work to examine and record the condition of the comb in a series of adult Barred Plymouth Rock hens. The hens from which the combs were taken for this work had been carefully and closely selected in their breeding for more than 25 years. During the last nine years they have been "line-bred." This means that no new "blood" had been introduced into the stock during that period. Consequently, the material is racially exceedingly homogeneous. Indeed it would be difficult to find anywhere material for the study of variation more homogeneous than that dealt with here. All the birds whose combs are included in this study were females, and adult. In age they varied from eleven months to about five years. The great majority of the birds were two years and over in age. Since the comb attains its full development within the first year of a hen's life and probably does not thereafter change in form—except as the result of accident or mutilation—this difference in the age of the different birds used is not significant. Mutilated combs were not included in the study.

As will presently be made clear to the reader, the comb is an exceedingly variable structure in fowls. It varies both in size and in form. So great and of such a peculiar character is this variation that its biometrical appreciation is a rather perplexing problem. *A priori* one would be inclined to say that fewer things would be easier than counting the number of points on a single comb, or measuring its height. Actually we have found it practically impossible to do either of these things directly in a satisfactory way. At the outstart of the work it was felt to be absolutely essential to get some kind of a picture of each individual comb. Practical considerations ruled photography out as a means of reaching this end. Resort was had to drawing the combs actual size with the aid of a camera lucida arranged not to magnify or distort the image. In this way one can get an accurate outline of the lateral aspect, or, more correctly, of a sagittal section of the comb. It was at first thought that it would be best to make such drawings with the comb still attached to the head. Experience showed however that this was not the case. More uniform and accurate representation of the base of the comb could be made if it was removed from the head. After this was learned all the combs were removed before they were drawn. They were cut off with a sharp scalpel, great care being taken to ensure that the cut evenly followed the contour of the top of the skull. The severed comb was put on a flat surface after removal, and the basal cut edge was made, as nearly as possible, a straight line. After the outline of each comb had been drawn, the *area* bounded by the outline of the comb was determined by means of an Amsler polar planimeter to tenths of a square centimetre. Our procedure was as follows: the area of every comb was measured twice; if the results of the two measurements did not agree, a third measurement was then taken. If this measurement agreed with one of the others, it was taken as the final result. If it did not agree with either of the other two, an average was taken of the three measurements and the average recorded as the area. Every effort was made to attain accuracy in the planimeter measurements, and it is believed that the figures given are substantially correct.

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* Cf. Davenport, C. B., "Inheritance in Poultry." *Carnegie Institute of Washington.* Publ. No. 52, p. 65. "The primitive form of the comb is the single comb seen in the wild species of the genus Gallus, and in most domestic races."

In addition to the comb area, the *length* of the comb was measured. This was done by placing a sliding arm-caliper on the outline drawings, and adjusting it so that the arms touched respectively the most anterior and posterior points of the comb outline, with the bar of the caliper parallel to the base of the comb. It was desired to measure the height of the comb, but attempts to do this directly failed. The reason for the failure will be apparent if one examines the figures. The top of the comb is an irregular, serrated line. It is quite a matter of accident which particular point of region of the comb happens to be highest. If one were to measure the height at different points in different combs, it is plain that one would not always be measuring morphologically identical or even comparable things. Thus, in one case (Fig. 27, Plate I.) the highest part of the comb might be at the very posterior end, and in another case well toward the anterior end (Fig. 93, Plate III.). Height measurements made on such a plan would have no particular significance. Yet comb-height is a very significant thing, particularly in cold climates. The tall comb (e.g., the Leghorn type) is much more liable to be frozen than is the low Plymouth Rock comb. It is highly important to get some measure of height in a study of comb variation. After a careful study of the problem we have reached the conclusion that a fairly trustworthy and significant measure of comb-height will be obtained if we take the height of a rectangle having a length and an area equal to that of the comb. We have accordingly determined this value for each of the combs, by dividing the measured area by the measured length. The values so obtained are designated as the "calculated heights." These measurements are given in Table I. The total number of combs included is 81.

TABLE I.

Data on Comb Variation.

Comb Number	Area in cm.^{2}	Length in mm.	Calculated height in mm.*	Comb Number	Area in cm.^{2}	Length in mm.	Calculated height in mm.*
1	3·9	47·4	8	*57*	8·3	60·9	14
2	7·6	61·5	12	*58*	4·7	53·4	9
3	4·3	53·4	8	*59*	5·3	56·0	9
4	7·7	57·8	13	*60*	4·1	49·1	8
5	5·5	47·6	12	*61*	3·6	43·6	8
6	3·4	49·3	7	*62*	7·5	54·8	14
7	9·5	61·5	15	*63*	4·8	54·8	9
8	4·1	45·4	9	*64*	4·5	41·8	11
9	3·9	49·2	8	*65*	12·7	62·3	20
10	3·6	46·4	8	*66*	7·5	54·9	14
11	3·4	37·3	9	*67*	5·2	47·9	11
12	5·1	54·9	9	*68*	4·7	46·0	10
13	7·0	56·8	12	*69*	4·6	43·2	11
14	5·0	49·0	10	*70*	7·2	51·0	14
15	1·8	37·3	5	*71*	7·0	48·9	14
16	5·6	57·6	10	*72*	3·7	42·3	9
17	5·7	54·8	10	*73*	8·7	56·6	15
18	4·7	48·7	10	*74*	6·8	51·4	13
19	7·4	62·6	12	*75*	5·3	51·4	10
20	4·2	46·0	9	*76*	7·5	54·2	14
21	4·3	55·4	8	*77*	4·8	45·9	11
22	8·1	61·8	13	*78*	7·0	51·4	14
23	5·6	53·0	11	*79*	7·5	51·6	15
24	5·1	55·5	9	*80*	5·6	49·4	11
25	3·9	49·4	8	*81*	8·5	57·0	15
26	4·6	54·0	9	*82*	7·2	52·6	14
27	4·7	46·0	10	*83*	1·5	35·4	4
28	4·7	45·5	10	*84*	1·6	35·0	5
29	4·1	51·0	8	*85*	1·3	32·4	4
30	7·2	56·9	13	*86*	4·7	45·0	10
31	3·5	45·5	8	*87*	5·1	42·8	12
32	4·2	51·3	8	*88*	6·4	47·2	14
33	4·2	55·4	8	*89*	2·4	38·6	6
34	2·5	37·4	7	*90*	5·2	47·2	11
50	8·7	63·6	14	*91*	5·8	52·2	11
51	4·2	48·7	9	*92*	8·6	66·7	13
52	5·3	48·3	11	*93*	13·3	72·7	18
53	2·2	45·5	5	*94*	8·5	61·2	14
54	6·2	56·3	11	*95*	5·4	42·8	13
55	4·3	52·7	8	*96*	3·8	45·1	8
56	7·4	60·3	12				

3. The actual outlines of the combs studied are shown, somewhat reduced in size, in Plates I. to III. Combs 35 to 49 inclusive present a different appearance

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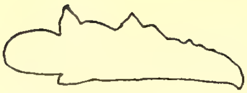
* The values tabled are the figures to the *nearest whole number*, obtained by dividing the area by the lengths.

PLATE I.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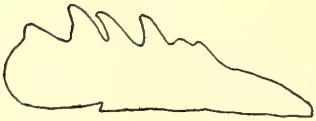
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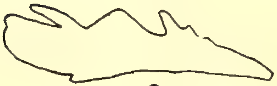
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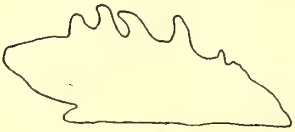
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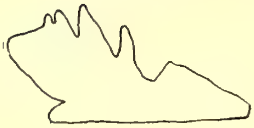
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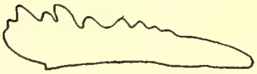
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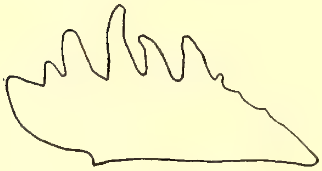
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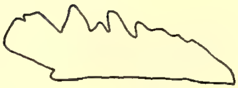
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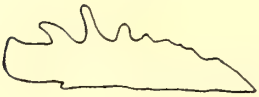
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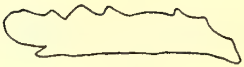
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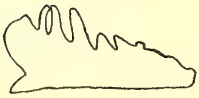
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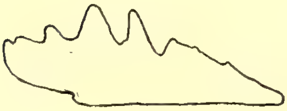
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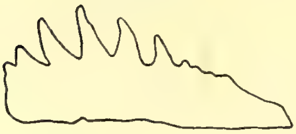
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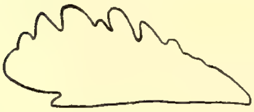
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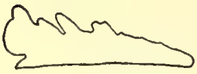
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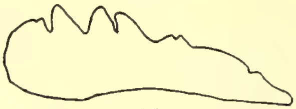
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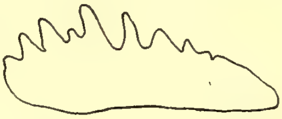
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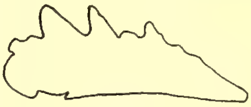
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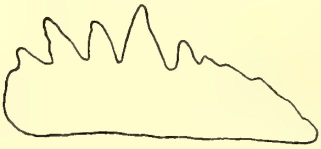
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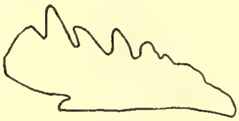
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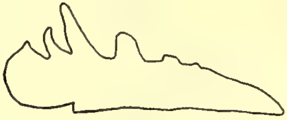
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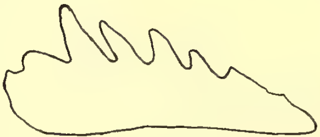
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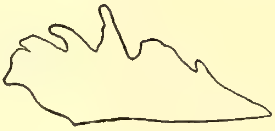
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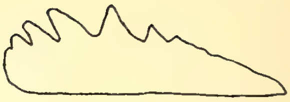
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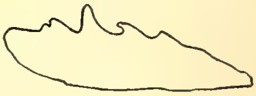
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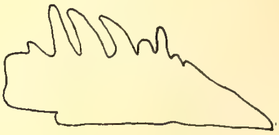
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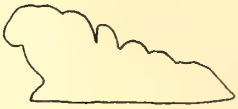
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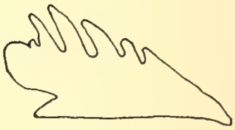
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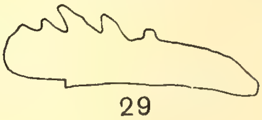
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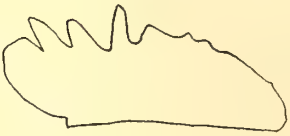
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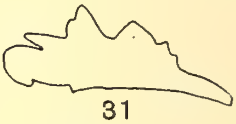
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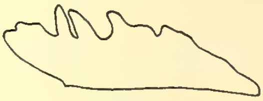
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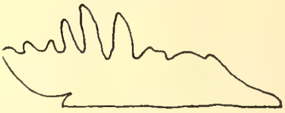
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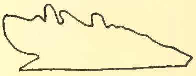
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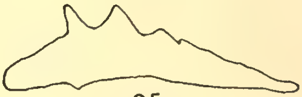
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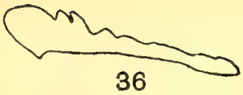
PLATE II.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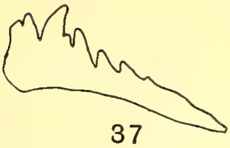
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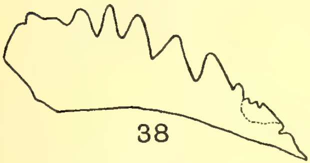
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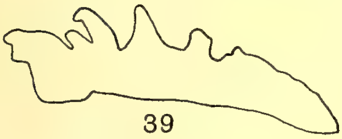
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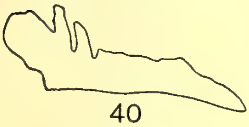
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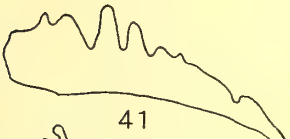
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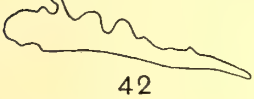
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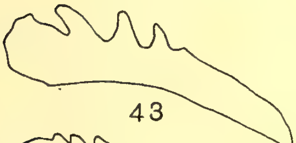
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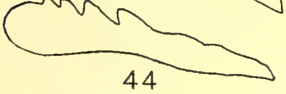
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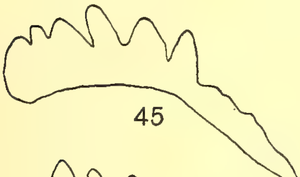
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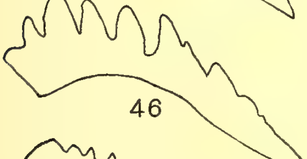
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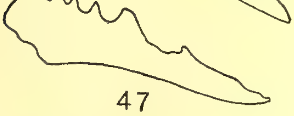
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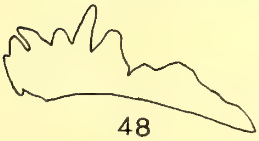
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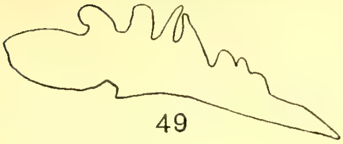
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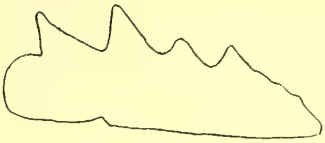
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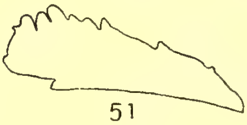
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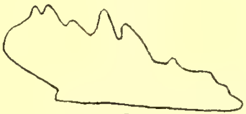
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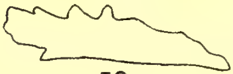
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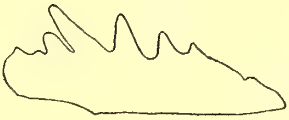
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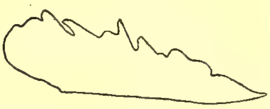
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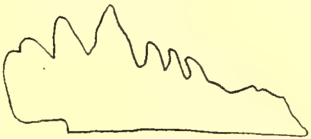
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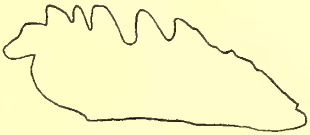
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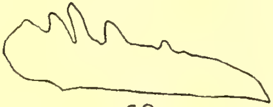
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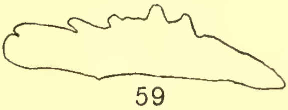
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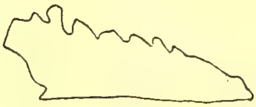
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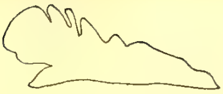
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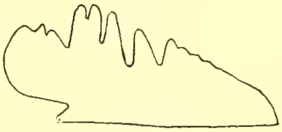
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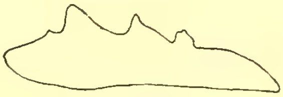
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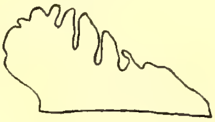
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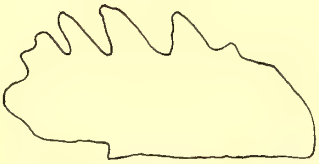
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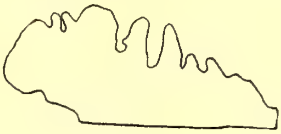
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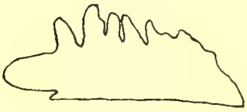
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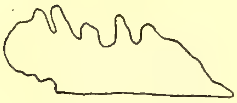
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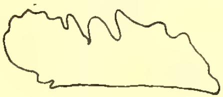
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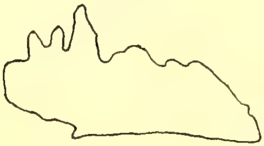
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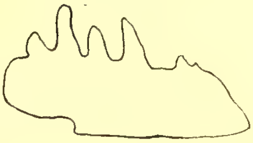
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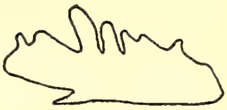
PLATE III.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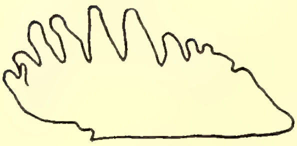
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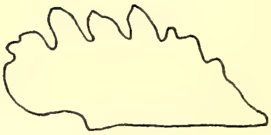
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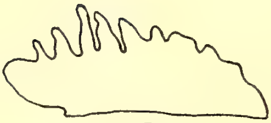
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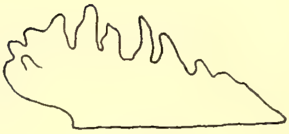
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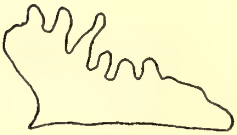
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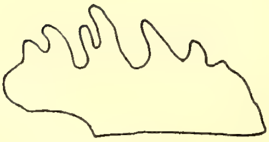
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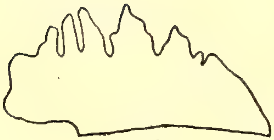
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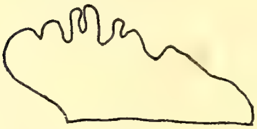
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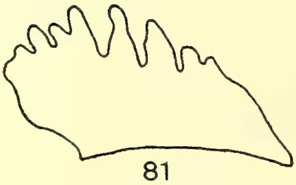
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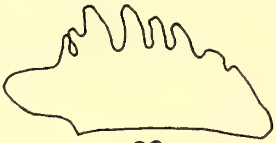
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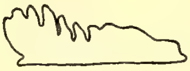
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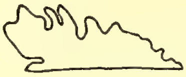
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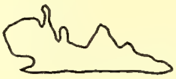
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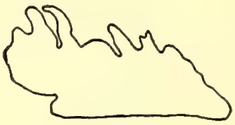
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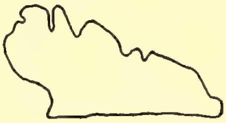
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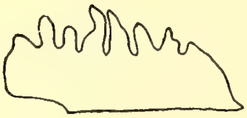
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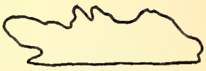
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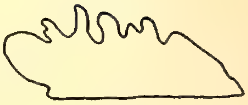
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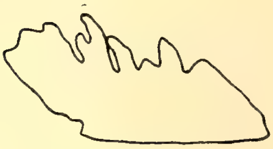
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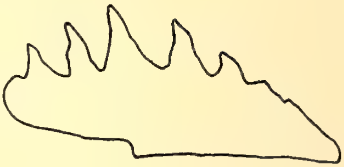
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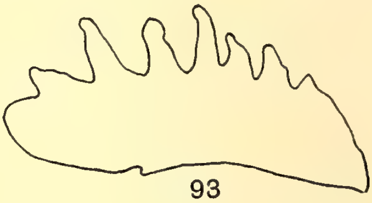
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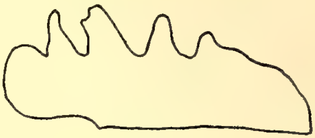
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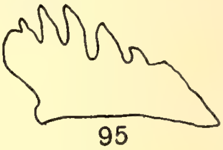
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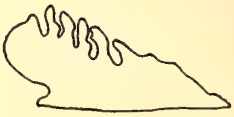
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from the others in that the base of the comb is less straight, and the comb is canted at an angle as a whole. This condition results from the fact that these combs were drawn without removal from the bird's head. It will be noted that measurements from them are not included in Table I.

An examination of these plates shows at once the extraordinary degree of variation which exists within a single comb type, even in the most homogeneous material. It is apparent that this variation involves both size and form of comb. We may first turn to a discussion of the variation in size shown in these combs.

4. The distributions of frequency for the 81 birds and the three characters measured are given in Table II.

TABLE II.

Frequency Distributions for Variation in Area, Length, and Calculated Height of Female Barred Plymouth Rock Combs.

AREA		LENGTH		CALCULATED HEIGHT	
Sq. cm.	Frequency	Mm.	Frequency	Mm.	Frequency
0·5— 1·4	1	32—34·9	1	3·5— 4·4	2
1·5— 2·4	5	35—37·9	5	4·5— 5·4	3
2·5— 3·4	3	38—40·9	1	5·5— 6·4	1
3·5— 4·4	18	41—43·9	6	6·5— 7·4	2
4·5— 5·4	21	44—46·9	11	7·5— 8·4	14
5·5— 6·4	8	47—49·9	15	8·5— 9·4	11
6·5— 7·4	9	50—52·9	10	9·5—10·4	9
7·5— 8·4	8	53—55·9	13	10·5—11·4	10
8·5— 9·4	5	56—58·9	8	11·5—12·4	6
9·5—10·4	1	59—61·9	6	12·5—13·4	6
10·5—11·4	0	62—64·9	3	13·5—14·4	11
11·5—12·4	0	65—67·9	1	14·5—15·4	4
12·5—13·4	2	68—70·9	0	15·5—16·4	0
		71—73·9	1	16·5—17·4	0
				17·5—18·4	1
				18·5—19·4	0
				19·5—20·4	1

The chief variation constants for these distributions are given in Table III.

TABLE III.

Constants of Variation in Size Characters of Single Combs.

Character	Mean	Standard Deviation	Coefficient of Variation
Area	5·59 ± ·17 cm.^{2}	2·24 ± ·12 cm.^{2}	39·97 ± 2·44 °/₀
Length	50·80 ± ·56 mm.	7·45 ± ·39 mm.	14·67 ± ·79 °/₀
Calculated Height	10·57 ± ·23 mm.	3·03 ± ·16 mm.	28·66 ± 1·64 °/₀

From these tables the following facts are to be noted:

(1) The average area of the combs of the females of the race of Barred Plymouth Rocks here discussed is in round numbers 5½ square centimetres. The average length of comb is a little over 5 cm. This indicates an average calculated height of 10½ mm. On account of the way in which the combs were removed (cf. p. 422), this represents the average height above the top of the *skull.*

(2) There is a high degree of variation, both absolute and relative, in regard to each of the size characters studied. The Barred Plymouth Rock female according to the American Standard of Perfection* has the comb "small, proportional to the size of the specimen, set firmly on the head, straight and upright, evenly serrated, having five well-defined points, those in front and at rear being somewhat smaller and shorter than the other three." The drawings and figures here presented show that in the absence of special selection in regard to comb size, the character shows a range of variation all the way from the condition shown in large combed types like the Leghorns to the very smallest of single combs (cf. for extremes, Figs. 85 and 93 of Plate III.).

(3) The amount or degree of variation, whether measured absolutely or relatively, is not the same for the characters measured. The area shows the highest and the length the lowest coefficient of variation. This relation is to be expected from the form of the comb. The chief factor in determining variation in area is the shape of the serrated portion of the comb. The figures of Plates I. to III. show how variable in shape the combs are. It must be remembered that the comb characters studied are not independent variables†.

5. We may turn next to the consideration of variation in the shape or form of the comb. In the typical single comb such as is shown, for example in Diagram A, there are to be distinguished four regions or parts which are morphologically distinct.

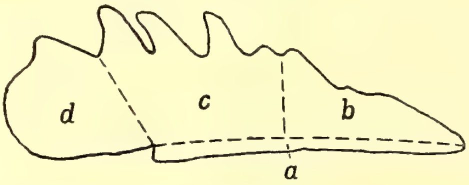

DIAGRAM A. Outline of a typical single comb removed from the head. The dotted lines indicate distinct regions of the comb. The comb outline of this figure is a copy of Figure 2, Plate I.

These regions may be designated as follows:

(1) A *basal region* (Diagram A, *a*) forming the attachment of the comb to the top of the skull. From the base springs the *vane*, or upright portion. In the vane are to be distinguished three portions as follows:

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* Published by American Poultry Association, 1906.

† The value of v_H is directly deducible from that of v_A and v_L when we know the correlation of area and length. We find for length and area correlation $r_{AL} = \cdot 845$, from $r_{AL} = (v_A{}^2 + v_L{}^2 - v_H{}^2)/(2v_A v_L)$.

(2) An *anterior region* (Diagram A, *b*) having its free border smooth or very slightly and irregularly serrated, typically never deeply and regularly serrated.

(3) A *middle, serrated region* (Diagram A, *c*). This is the region of the deep and characteristic serrations on the free border of the comb.

(4) A *posterior region* or *blade* (Diagram A, *d*) typically having its dorsal, posterior and ventral borders free, and lying wholly behind the posterior end of the base (*a*) of the comb.

A study of the figures in Plates I. to III. makes it evident that variation occurs in respect to each of these comb regions. A summary catalogue of these variations is presented because of its possible usefulness in classifying single comb variations in breeding work. The several regions enumerated are considered in order.

The *basal region* (*a*) may be *present* or *absent*. When present it varies in height above skull, showing all gradations between entire absence and a height of several millimetres. In some cases (for example, Figs. 16, 17 and 19) the vane is directly attached to the skull without any intervening, morphologically distinct base. In the living bird this condition most obviously manifests itself by the ventral edge of the blade lying close down to the head. This condition was observed in 6 out of the 81 combs measured.

The *anterior portion* (*b*) may vary in regard to the following particulars *:

(1) *Relative extent*. (Compare Figs. 2, 22, 30, 36, 40, 50, 65, 78 and 93.) This region reaches back over considerably more than half the length of the comb in some cases, and only a short distance in others.

(2) *Character of serration* varies all the way from a perfectly smooth free margin (Figs. 2, 29, 43 and 63) through a condition of fine and regular serration (Figs. 8, 9, 62, 84 and 86) to a condition of coarse and irregular points in this region of the comb (Fig. 75).

(3) *General shape* varies from the condition in which the free border is generally convex (Figs. 29, 30, 54, 63, 69, 70, 93, 94) through the condition where the border is approximately straight (Figs. 7, 12, 26, 28) to the concave or excavated border (Figs. 23, 31 and 33).

The *middle or serrated portion* (*c*) may vary in respect to:

(1) *The depth of the serrations*. The serrations may be broad and deep (Figs. 13, 19, 24, 92 and 94), or broad and shallow (Figs. 10 and 89), or narrow and deep (Figs. 11, 26, 75, 88 and 96), or, finally, they may be shallow and narrow (that is set close together, Figs. 27 and 51). All degrees of gradation between these classes are represented among the combs.

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* It is to be understood that the references to figures given in parentheses in this section are intended merely as illustrations, and not as complete, statistical inventories of all the combs falling within each of the several categories. The attempt is made simply to refer to several clear illustrations of each class.

(2) *Number of points.* While, as is evident from an inspection of the figures, it is impossible accurately to count the number of points in each comb, owing to the difficulty in defining how great the projection of the margin must be in order to be designated as a point, yet it is obvious that there is a great deal of variation in regard to this character. Such combs as are shown in Figs. 7, 17, 26, 64, 73, 76 and 88 obviously have more points than do such combs as are shown in Figs. 3, 12, 18, 31, 44, 50, 63, 89 and 94. There is further no doubt that there is continuous variation between the extremes in respect to the number of points.

(3) *The extent of the serrated region.* The region of large and distinct points may extend over nearly the whole of the comb (Figs. 7, 22, 38, 46, 88 and 93), or it may be confined to a restricted region of the comb (Figs. 29, 33 and 58).

(4) *The direction of the points.* The angle which the points make with the base line of the comb varies in a continuous manner from the condition in which they form approximately a right angle with the comb base (Figs. 7, 62, 64, 66 and 96), to the condition where they slope in a posterior direction at a pronounced angle (Figs. 2, 13, 15, 22, 28 and 65) or to the condition where they point forward (Figs. 48 and 77).

(5) *Intercalated points.* It happens rather frequently in the single comb that a small point or serration will be set between two larger ones in the series. Examples of such intercalation are shown in Figs. 8, 14 and 17.

(6) *Branched or split points, and points with spurs.* The combs studied rather frequently have one or more of the points either branched or split at the tip, or bearing on either the anterior or the posterior side a small spur or secondary point. Examples of this sort of point variation are seen in Figs. 37, 46, 62, 66, 78, 79, 80, 82, 86, 88, 90, 91 and 94.

The *blade of the comb* (*d*) varies in respect to:

(1) *The condition of the dorsal free margin or border.* This margin of the blade may be smooth (Figs. 4, 5, 10, 30, 49, 50, 82 and 94) or it may be serrated (Figs. 7, 12, 21, 22, 26, 33, 56, 69, 75 and 76).

(2) *The contour of the posterior and ventral free borders.* These borders of the blade may be either smooth (condition shown in the majority of the figures) or they may be to a greater or less extent indented and of irregular contour (Figs. 12, 23, 31, 39, 48, 51 and 61).

(3) *The degree of extension behind the posterior end of the base of the comb.* The blade may lie nearly or wholly behind the posterior end of the comb base as in the normal case (shown in the majority of the figures), or, on the other hand, little or none of the blade may lie behind this point (Figs. 11, 15, 37, 77, 83, 84, 85 and 95). There are all intergrades between these extreme conditions.

(4) *The angle made with the base of the comb.* The blade may be set on the comb in such a way that its chief axis is approximately in line with the chief axis of the comb (Figs. 4, 9, 10, 26, 42, 49, 50, 67 and 94), or it may be tilted up so that its axis forms different angles with the rest of the comb (Figs. 3, 8, 11, 15, 20, 30, 32, 62, 64, 77, 80 and 87). It is even possible that the blade may be tilted downward with reference to the rest of the comb as is shown, for example, in Fig. 35.

6. The comb as a whole may vary in form in certain other respects beyond those enumerated. Some of these variations are not shown in the series of figures here presented. Among such variations are to be included lopping of the comb, such as is a normal breed characteristic of Leghorn hens, and of other breeds having a very large single comb. The comb may also be wrinkled or puckered. This condition is brought about when the area of the vane of the comb is too great for the base, and consequently puckering of the free border of the vane occurs. An example of this condition is indicated by the dotted line in Fig. 38.

Another variation of the single comb is that in which side sprigs or points occur. Examples of this variation are shown in Figs. 73 and 76. These side sprigs occur with tolerable frequency among single comb breeds of fowls. They usually appear more often in the males than in the females. The fancier must constantly be on his guard to keep this form of comb from appearing among his exhibition birds. The occurrence of this comb variant is of particular interest from the theoretical side, because there is strong reason to regard it as an incipient transitional or intermediate form between the pure single and the pure pea types of comb. The pea comb differs from the single comb in that in addition to a central ridge corresponding to the vane of the single comb, it has two lateral serrated ridges of comb substance. Neither the central nor the lateral ridges of the pea comb are nearly as high as is the vane of the single comb. The low, compact form of the pea comb is one of the characteristic features which distinguish it from the single comb. Side sprigs occurring on the single comb appear in just the place where the lateral ridges of the pea comb lie in the corresponding region of the comb. Davenport (*loc. cit.* p. 66) says of them: "Now such side sprigs are morphologically equivalent to the lateral ridges of the pea comb." When the side sprigs are present, they are usually found near the posterior end of the comb. It is a well-known fact to breeders who handle pea comb birds that when the pea comb is partially defective it is usually at the posterior end alone that the three ridges (central and two laterals) are found.

That intermediate forms between the pea comb and the single comb occur has been known for some time. In 1902 Bateson*, in describing the results of crossing White Leghorns (single comb) and Indian Games (pea comb) says: "In the cross-bred the comb is almost always either a true single comb, differing from the White Leghorn in diminution of size; or an intermediate pea. Of the latter there are many degrees." In a further paragraph, he says: "In later life the distinction between intermediate and single may become very obvious; but even though the comb may grow up to some height, the three ridges of the pea comb remain marked. The intermediate pea comb in both sexes usually lies either on one side or the other, like that of the Leghorn hen." The existence of intermediates between these comb types has been confirmed by Davenport (*loc. cit.*), who says (p. 35), in discussing the comb form of B. Minorca × Brahma hybrids: "In all cases the pea comb of the Brahma dominates over the single comb. Critical examination shows, however, that the pea comb of the hybrid is not always typical. Frequently the whole structure, and especially the median ridge, is abnormally high (Fig. 21), and, on the other hand, in a few cases the lateral ridges are hard to make out. The dominance is imperfect." Such intermediates between single and pea combs are very well shown in Davenport's Figs. 20 and 21.

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* Report to the Evolution Committee of the Royal Society. Report I, 1902, p. 94.

We have obtained the same result in our own hybridizing experiments with single and pea comb crosses. In the F_1 hybrids the combs frequently are high and have a deeply serrated dorsal border. Such a condition is never found, so far as we are aware, in fowls pure bred in respect to pea comb. At the same time, these hybrid birds exhibit unmistakable traces of the lateral ridges which are typical of the pea comb. It would be hard to conceive of a more perfect intermediate form between the pea and the single comb type than is afforded by such birds.

Summarizing the facts brought out by the inventory of qualitative variations exhibited in these combs it may be said that there appears to be continuous variation, considerable in amount, in every definable characteristic of the comb. All degrees of intergradation between the extreme conditions of each of these characteristics regularly occur.

EXPLANATION OF PLATES.

All figures are reduced to one-third.

Plate I.	Outlines of Combs 1 to 35.
Plate II.	Outlines of Combs 36 to 71.
Plate III.	Outlines of Combs 72 to 96.

MISCELLANEA.

I. Fecundity of Swine*.

By FRANK M. SURFACE, Ph.D.

During the course of certain investigations in the laboratory of the Maine Agricultural Experimental Station it became desirable for purposes of comparison to have data on other fecundity distributions than those already accessible in the literature. In this connection it was decided to fit frequency curves to the data published some time ago by Mr George Rommel† on the fecundity of brood sows. A large amount of data relating to the size of litters produced by registered sows of two breeds, Duroc Jersey and Poland China, had been extracted from the stud books and published by this writer. The raw material is given in the form of frequency distributions for single years. In the case of the Poland China sows the statistics were taken from two sources: viz., the American Poland China Record and the Ohio Poland China Record. In each case two five year periods, 1882–1886 and 1898–1902, were selected for comparison. Tables I, II, IV and V of the above-mentioned circular give the raw data for each year as obtained from the two sources.

For the Duroc Jersey data the National Duroc Jersey Record was used. Tables VIII, IX and X give the number and size of litters registered for each of the fifteen consecutive years from 1888 to 1902. In this case the earlier years contained relatively few records.

In all cases however, and especially for the later years, the number of litters dealt with was very large. For this reason the statistics are of considerable value. No reductions other than the means for each year were given in the original paper. Later Rommel and Phillips‡ in a similar set of data for the year 1902 studied the inheritance of size of litter from Poland China sows. In the course of this work the standard deviations and coefficients of correlation were determined. The data with which the present paper deals have never been reduced although the variation constants in the case of Poland China sows are, as would be expected, of the same order of magnitude as those found by Rommel and Phillips. The reductions given here were originally made for the purpose of comparison with other data then being studied, but it seems worth while to put these constants on record. To do so is the purpose of this paper.

The data for a single year for each breed were picked out and submitted to analysis. In each case the year selected was that which contained the largest number of litters. For the Poland China the data given by the American Poland China Record for 1902 were used. The number of litters recorded in this year was 6,627. In the case of the Duroc Jersey breed the records given by the National Duroc Jersey Record for the same year, 1902, were used. The number of litters recorded in this case was 6,109.

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* Papers from the Biological Laboratory of the Maine Agricultural Experiment Station, No. 3.

† Circular, No. 95. Bureau of Animal Industry, U. S. Department of Agriculture, Washington, D.C. 1906.

‡ *Proceedings of American Philosophical Society*, Vol. XLV. pp. 245—254, 1907.

The chief constants measuring the variability in the fecundity of these two breeds for the year 1902 are given in Table I.

TABLE I.

Constants for Variation of Fecundity in Brood Sows.

Constant	Poland China	Duroc Jersey
Mean	7·435 ± ·010	9·337 ± ·021
Standard Deviation ...	2·038 ± ·013	2·427 ± ·016
Coefficient of Variation ...	27·411 ± ·172	25·997 ± ·169

The first thing noted here is the large difference in the values of the means. This, as Rommel has pointed out, confirms the common observation that Duroc Jersey sows are more prolific than the Poland China. The difference of almost two pigs is very marked. In the constants measuring the variability of the two breeds only a small difference is found. The standard deviation is slightly larger in the Duroc Jersey. When considered with reference to the mean, however, it is seen that the coefficient of variation is larger in the Poland China by nearly 1·5 per cent. This when taken in connection with its probable error, which for the difference of these two quantities is ±0·241, is to be regarded as certainly significant.

Considering the coefficient of variation with reference to fecundity in other animals we find that this value is somewhat lower than the average. Fecundity like many other physiological characters appears to have a high coefficient of variability. Powys* finds that for man the number of children exhibits a coefficient of more than 48 °/₀. For the horse Pearson † finds a value slightly less than 25 °/₀. For mice the data given by Weldon ‡ lead to a coefficient of variation of 37·5 °/₀. In the case of ovulation of the domestic hen § the coefficient of variation averages 34·2 °/₀.

Table II gives the analytical constants which exhibit the further characteristics of these distributions. The material was not grouped, nor were Sheppard's corrections used. The unit for the moments is one pig.

It may first be noted that for the skewness shown by these distributions we have the values of +0·05 and +0·07. The probable error for each is ±0·01. Thus there is a small but significant positive skewness. The Poland China with the smaller mean and larger variability shows a slightly larger skewness. However, the difference is so slight that it cannot be regarded as very important. Comparing the skewness of these distributions with fecundity and fertility curves for other organisms, we find that it is of about the same magnitude as that given by Powys for man, viz. +0·08 ||. Schuster**, however, gives data for the size of human families with one or more congenitally deaf persons, which lead to a skewness of about +0·43. For fecundity of mares Pearson gives a value of nearly −0·13. In the domestic hen the skewness has an average value of −0·21.

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* *Biometrika*, Vol. IV. p. 251, 1905. [Various values from 47 to 70 are deducible from Pearson and Lee's data, *Phil. Trans.* 1899, Vol. 192, A, pp. 280—90.]

† *Biometrika*, Vol. I. pp. 289—292, 1902. Only the moments are given here.

‡ *Biometrika*, Vol. V. p. 442, 1907.

§ Pearl, R. and Surface, F. M. In a bulletin of the Bureau of Animal Industry, U. S. Department of Agriculture, Washington, D.C., now in press.

|| [There appears to be a slip here. Powys' only comparable data occur *Biometrika*, Vol. IV. p. 251 and give skewness = ·38, and this does not wholly exclude the sterile cases as in the sow data. ED.]

** *Biometrika*, Vol. IV. 1906, p. 474. [Pearson's data give Anglo-Saxons ·56, Danes ·42, *Chances of Death*, Vol. I. pp. 75—88, 1897.]

TABLE II.

Analytical Constants for Variation of Fecundity in Brood Sows.

Constant	Poland China	Duroc Jersey
μ_2	4·1538	5·8922
μ_3	1·4259	1·8494
μ_4	58·0100	116·1018
β_1	·0284	·0167
$\sqrt{\beta_1}$	·1684	·1293
β_2	3·3622	3·3442
$\beta_2 - 3$	·3622	·3442
κ_1	·6392	·6381
κ_2	·0336	·0198
Skewness	·0701	·0539
Modal divergence ...	·1429	·1308
Standard deviation .	2·0381	2·4274
Mean	7·4353	9·3372
Median	7·8754*	9·7631*
Mode	7·2924	9·2064
Modal frequency ...	1344·04	1039·0000
Origin	5·7270	7·7770
y_0	950·2781	850·5350

The modal divergence has values of 0·131 and 0·143, and the probable errors of these quantities on the assumption of normality are ±0·026 and ±0·021 respectively. Since the lower value is more than five times its probable error, there can be no doubt that we are dealing with skew variation.

Turning to the kurtosis, it is seen that $\beta_2 - 3$ is positive and equal to about 0·35. The probable error of β_2 on the assumption of a normal distribution is ±0·04 for the two cases. This indicates that these curves are significantly leptokurtic. The deviation from the mesokurtic condition of the normal curve is more than eight times its probable error.

Since $\kappa_1 (= 2\beta_2 - 3\beta_1 - 6)$ is positive and κ_2 greater than 0 and less than 1 we have the conditions for a Type IV curve in each case. The equations to the two curves are as follows:

For the Poland China

$$y = \frac{950{\cdot}2781}{\left[1 + \left(\frac{x}{9{\cdot}1609}\right)^2\right]^{11{\cdot}9532}} \cdot e^{4{\cdot}0851 \tan^{-1} x/9{\cdot}1609}.$$

For the Duroc Jersey

$$y = \frac{850{\cdot}5350}{\left[1 + \left(\frac{x}{10{\cdot}9825}\right)^2\right]^{11{\cdot}9415}} \cdot e^{3{\cdot}1088 \tan^{-1} x/10{\cdot}9825}.$$

The frequency polygons and fitted curves for these two distributions are shown in Figures 1 and 2 respectively (p. 436). The graduation is very close in both cases. The distributions for several other years were calculated far enough to determine that they would lead to the same type of curve. This indicates that the present curves give us the manner of the distribution of fecundity as measured by size of litter in these breeds of swine. So far as the writer knows, distributions of fecundity in other organisms have led to either Type I or Type II (or occasionally to a normal curve). That is to say, from the meagre data at present available it would appear that fecundity distributions do not usually lead to skew curves with unlimited range in both directions, but on the contrary to some type of limited range curve.

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* These are the *observed* values of the median.

Fig. 1. Frequency histogram and fitted curve for variation of fecundity of Poland China sows.

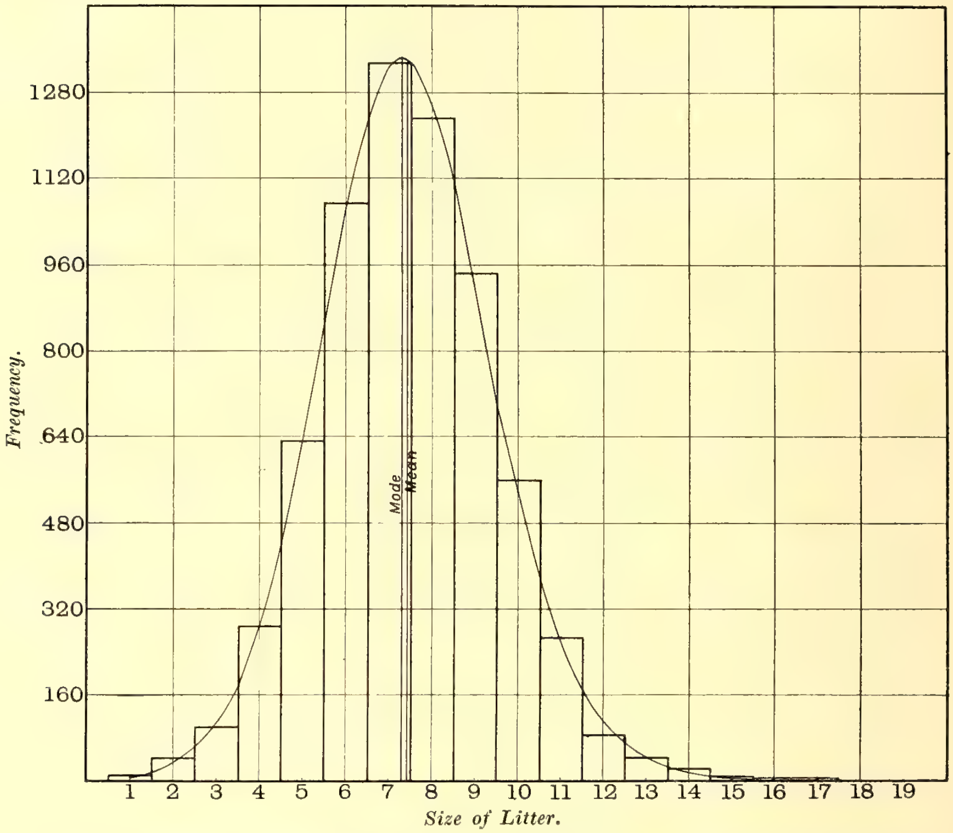
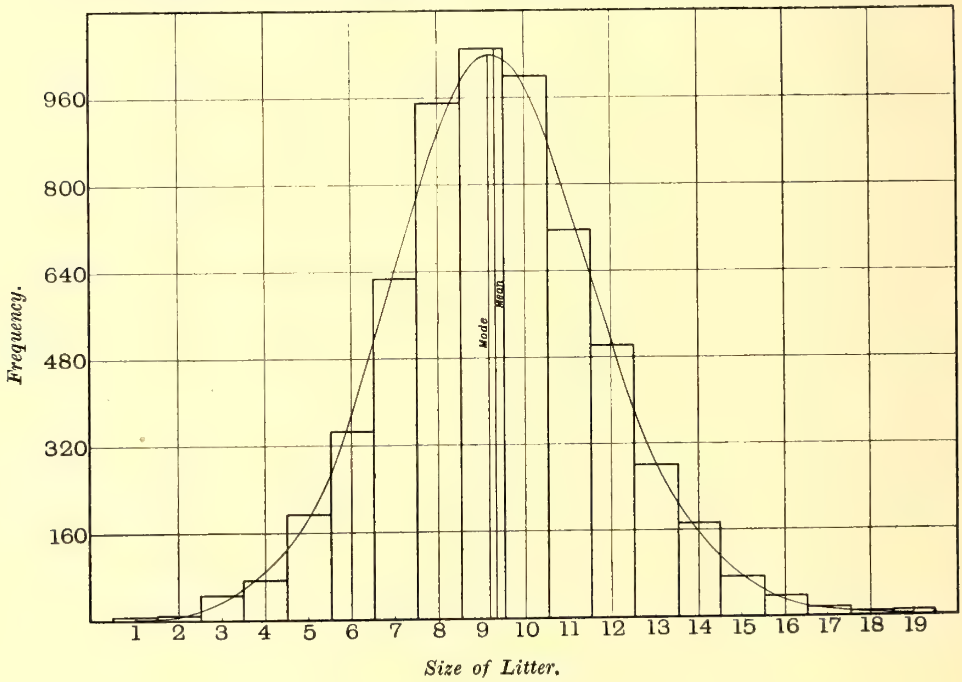


Fig. 2. Frequency histogram and fitted curve for variation of fecundity of Duroc Jersey sows.



II. The Frequency Constants of a Variable $z = f(x_1, x_2)$*.

BY RAYMOND PEARL, PH.D.

It often happens in practical biometric work that one desires to find the frequency constants of a compound character, from a previous knowledge of the constants of the separate components. Thus, for example, one measures the length, the breadth, and the height of each of a series of skulls. He wishes to know at least the mean and the standard deviation of the diametral product ($L \times B \times H$). There are two ways open to find the values of these constants. On the one hand the length, breadth, and height may be multiplied together for each individual skull, a frequency distribution of the products made, and the constants calculated in the ordinary way; or, on the other hand, by the use of the appropriate formulae one can deduce straight off the constants for the product knowing those for the components which enter into the product. The latter procedure will obviously effect a great saving of labour.

The formulae for determining the mean and standard deviation of a character $z=f(x_1, x_2)$ when the same constants and the coefficient of correlation for x_1 and x_2 are known, are well known to mathematicians. The writer ventures to think, however, that they are not so familiar to many of those who have approached the field of biometry along the biological pathway. For the convenience of such it seems desirable to publish all together those formulae of the sort under discussion which are most likely to be used in practical work.

The general method of deducing these formulae will be clear to anyone who will carefully study Pearson's paper "On a Form of Spurious Correlation which may arise when Indices are used in the Measurement of Organs†," wherein the formulae for $z=\frac{x_1}{x_2}$ are discussed. The general formulae for $z=f(x, y)$ will also be found discussed in the *Phil. Trans.* Vol. 187 A, p. 278, 1896.

In the formulae given in Table I the various letters have the following meanings:

x_1, x_2 and x_3 the separate characters involved in the compound character z.

m_1, m_2 and m_3 the means of the characters x_1, x_2 and x_3.

σ_1, σ_2 and σ_3 the standard deviations of x_1, x_2 and x_3.

$v_1=\frac{\sigma_1}{m_1}$, $v_2=\frac{\sigma_2}{m_2}$, $v_3=\frac{\sigma_3}{m_3}$. (The v's are the ordinary coefficients of variation *divided by* 100.)

r denotes the coefficient of correlation between the two characters designated by the subscripts.

The table gives the formulae for the mean and standard deviation of

(*a*) the sum of two and of three variables,
(*b*) the difference of two variables,
(*c*) the product of two and of three variables,
(*d*) the quotient of two variables (index).

In certain of the cases the formulae are approximations, but very close ones. The nature of the approximations made is indicated in the table.

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* Papers from the Biological Laboratory of the Maine Agricultural Experiment Station, No. 4.

† *Proc. Roy. Soc.* Vol. 60, pp. 489—498, 1897.

TABLE I.

Constants of $z=f(x_1, x_2)$.

$z=f(x_1, x_2)$	Mean of z	Standard Deviation of z
$z=x_1+x_2$	m_1+m_2	$\sqrt{(\sigma_1^2+\sigma_2^2+2r_{12}\sigma_1\sigma_2)}$
$z=x_1+x_2+x_3$	$m_1+m_2+m_3$	$\sqrt{(\sigma_1^2+\sigma_2^2+\sigma_3^2+2r_{12}\sigma_1\sigma_2+2r_{13}\sigma_1\sigma_3+2r_{23}\sigma_2\sigma_3)}$
$z=x_1-x_2$	m_1-m_2	$\sqrt{(\sigma_1^2+\sigma_2^2-2r_{12}\sigma_1\sigma_2)}$
$z=x_1 . x_2$	$m_1 m_2+r_{12}\sigma_1\sigma_2$	$m_1 m_2 [v_1^2+v_2^2+2r_{12}v_1 v_2+v_1^2 v_2^2(1+r_{12})]^{\frac{1}{2}}$,* or approximately $m_1 m_2 [v_1^2+v_2^2+2r_{12}v_1 v_2]^{\frac{1}{2}}$
$z=x_1 . x_2 . x_3$	$m_1 m_2 m_3 [1+r_{12}v_1 v_2+r_{13}v_1 v_3 + r_{23}v_2 v_3]$	$m_1 m_2 m_3 [v_1^2+v_2^2+v_3^2+2r_{12}v_1 v_2+2r_{13}v_1 v_3 + 2r_{23}v_2 v_3]^{\frac{1}{2}}$ approximately
$z=\frac{x_1}{x_2}$	$\frac{m_1}{m_2}(1+v_2^2-r_{12}v_1 v_2)$	$\frac{m_1}{m_2}\sqrt{(v_1^2+v_2^2-2r_{12}v_1 v_2)}$

III. The Correlation between a Variable and the Deviation of a Dependent Variable from its Probable Value.

By J. ARTHUR HARRIS, Ph.D., Carnegie Institute, Station for Experimental Evolution, Long Island, U.S., and Biometric Laboratory, University College, London.

The degree of interdependence of two quantitatively measurable variables is conveniently expressed by the correlation coefficient, *r*, or the correlation ratio, η. These constants will both be used with increasing frequency to describe many relationships in evolutionary, morphological and physiological work.

There appear to be, however, certain problems in which the correlation coefficient, while indispensable, does not yield all the information which we require.

Take such a case as the relationship between the number of eggs per clutch and the number of birds hatching. The limits of the number of birds hatching per nest are fixed by the number of eggs laid, and it may be designated as the dependent variable. It is quite clear that if a fixed proportion of the eggs hatched the correlation between the number of eggs and the number of birds would be perfect.

The biologist can suggest many analogous cases; for instance number of flowers per inflorescence and number of fruits developing, number of ovules formed and number of seeds maturing.

[* This formula, given by me to Mr J. F. Tocher, depends on the assumption of normal correlation, see *Biometrika*, Vol. IV. p. 320. The approximate value depends on neglecting higher powers of the coefficients of variation. The formula for the mean of the double product (Tocher, *loc. cit.*) is exact. The formula for the mean of the triple product is not exact, any more than the formula for the S.D. of the triple product (see Tocher, *loc. cit.* p. 321). The formulae for the mean and S.D. of an index are only true to the lowest powers in v_1 and v_2, and must not be applied if v_1 and v_2 are large. The formulae for $z=x_1 \pm x_2$, the sums or differences of any number of variables, are of course exact for both mean and S.D. ED.]

The interpretation of the correlations between such characters as these demands a little caution. Suppose we have a series of coefficients of correlation for number of ovules formed and number of seeds developing per pod in various species. It will be quite clear that the species in which the value of r is the highest are those in which the number of ovules per pod has the largest influence upon the number of seeds developing per pod, but we are not at all justified in concluding for any individual series that the pods with the larger number of ovules have a greater, or less, capacity, relative to the number of ovules they produce, for maturing seed.

Suppose that we have a population of individuals in which we recognize the two characters, x and y, and that y is merely a proportion of x which varies from individual to individual. Our problem is to determine whether the relative value of y changes from the lower to the higher grades of x.

Clearly the most probable value of y for any individual is px, where

$$p=\bar{y}/\bar{x},$$

and $\bar{x}$ and $\bar{y}$ are the mean values of the two characters in the whole population. Now we may take $z=y-px$, or the deviation of the y of any individual from its most probable value. If we can discover the correlation between x and z we shall have a convenient measure of any organic influence which x may have upon the relative value of y. It is undesirable to correlate x with the ratio y/x because of the spurious correlation which it introduces.

Using the differential notation to represent variations, we get

$$\delta x\delta z=\delta x\,(\delta y-p\,\delta x),$$

and summing and dividing by the number of pairs, we have

$$\sigma_x\sigma_z r_{xz}=\sigma_x\,\sigma_y r_{xy}-p\,\sigma_x^2.$$

Hence

$$r_{xz}=\frac{\sigma_y r_{xy}-p\sigma_x}{\sqrt{\sigma_y^2+p^2\sigma_x^2-2p\sigma_x\,\sigma_y\,r_{xy}}}\quad\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\text{(i)}.$$

If $r_{xz}=0$, or y be proportional to x in every case, then

$$r_{xy}=\frac{p\sigma_x}{\sigma_y}=\frac{V_x}{V_y}\quad\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\text{(ii)}.$$

Of course (ii) will never be absolutely true in practice. It gives, however, a quick test of the sign of the correlation coefficient r_{xz}. When $V_x/V_y<r_{xy}$ the correlation r_{xz} is positive and when $V_x/V_y>r_{xy}$ it is negative.

(i) may be written

$$r_{xz}=\frac{V_y r_{xy}-V_x}{\sqrt{V_x^2+V_y^2-2V_xV_yr_{xy}}}=\frac{r_{xy}-V_x/V_y}{\sqrt{1+(V_x/V_y)^2-2\,(V_x/V_y)\,r_{xy}}}=\frac{r_{xy}-V_x/V_y}{\sqrt{1-r_{xy}^2+(r_{xy}-V_x/V_y)^2}}\ldots\ldots\text{(iii)}.$$

For practical purposes (iii) is the most convenient formula to use in calculations. V_x and V_y are usually wanted for other purposes and will have been calculated already. The value for $1-r_{xy}^2$ will have been calculated already in obtaining the probable error of r_{xy}. Beyond this the calculation of r_{xz} can be completed in a few minutes if formula (iii) be adopted.

This formula has already been rather extensively used in series of data which will be published shortly, but I give the following illustrations of the kind of problems to which it may be applied.

Illustration I. Correlation between the number of flowers per inflorescence and the number of developing fruits in *Staphylea trifolia.*

Table I. shows the correlation between the number of flowers formed and the number of immature fruits at the time of counting for 270 inflorescences of *Staphylea trifolia* from the North American Tract of the Missouri Botanical Garden. The countings of the number of flowers and fruits were made incidentally while an investigation of the development of the fruit was being carried on. The series is a short one and represents the inflorescences at

TABLE I.

Staphylea trifolia.

Flowers per Inflorescence.

Developing Fruits.	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*	*21*	*22*	*23*	*24*	*25*	*26*	*27*	*28*	*29*	*30*	*31*	Totals
1	3	—	3	2	2	3	3	2	1	4	1	2	2	1	1	—	—	—	—	2	—	—	—	—	—	—	—	—	—	—	—	32
2	—	10	4	5	5	5	15	7	1	6	3	4	2	—	—	—	2	—	1	—	—	—	—	—	—	—	—	—	—	—	—	70
3	—	—	14	6	3	6	9	7	4	4	—	1	2	—	—	—	1	1	1	—	—	—	—	—	—	—	—	1	—	—	—	60
4	—	—	—	10	2	3	4	2	3	5	1	4	2	—	1	—	1	—	—	—	—	1	2	—	—	—	—	—	—	—	—	41
5	—	—	—	—	4	2	4	3	2	3	3	4	1	1	1	1	—	—	—	—	—	—	1	—	—	—	—	1	—	—	2	33
6	—	—	—	—	—	4	1	—	2	1	—	1	—	—	1	—	1	—	—	—	2	—	—	—	—	—	—	1	—	1	—	15
7	—	—	—	—	—	—	—	2	—	—	—	1	—	1	1	1	2	—	—	1	1	—	—	—	—	—	—	—	1	—	—	11
8	—	—	—	—	—	—	—	—	—	—	—	2	—	—	—	—	—	1	—	—	—	1	—	1	—	—	—	—	—	—	—	5
9	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
10	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	1	—	—	—	—	2
Totals	3	10	21	23	16	23	36	23	13	23	8	19	9	3	5	3	7	2	2	4	3	2	3	1	0	0	1	3	1	1	2	270

a time when no fruits had attained a length of over 20 mm. It is quite probable that many of the fruits which were still developing when the material was examined would have fallen later. Thus while the investigation of the relationship between the number of flowers and the number of fruits developing per inflorescence during the time that the ovaries which fail to develop are being eliminated presents some points of particular interest, conclusions drawn from one series cannot be applied to any other of the same species. The series is here given merely as an illustration of a statistical method.

Number of flowers furnishes our x character and number of fruits developing our y character. For constants we get

$$\begin{array}{ll}
\text{Mean } x = 9{\cdot}193 \pm {\cdot}243, & \text{Mean } y = 3{\cdot}396 \pm {\cdot}074, \\
\text{S. D. } x = 5{\cdot}924 \pm {\cdot}172, & \text{S. D. } y = 1{\cdot}801 \pm {\cdot}052, \\
V_x = 64{\cdot}444, & V_y = 53{\cdot}038, \\
p = {\cdot}369, & V_x/V_y = 1{\cdot}215, \\
r_{xy} = {\cdot}457 \pm {\cdot}033. & r_{xz} = -{\cdot}649 \pm {\cdot}024.
\end{array}$$

These figures seem to indicate that while there is a positive correlation of ·457 between the number of flowers per inflorescence and the number of fruits developing, the inflorescences are not all affected alike in the large elimination of ovaries which takes place. Only a portion of the flowers formed can develop into fruits, and the negative correlation of − ·649 seems to show that the larger inflorescences lose not only actually but *relatively* more of their ovaries than do the smaller ones. But this conclusion can be applied only to this particular series of data. It may be found later that after the elimination is complete the correlation between the number of flowers and the deviation of the number of fruits per inflorescence from their probable number will rise to sensibly 0, or take a substantial positive value.

Illustration II. Correlation between the number of ovules per pod and the number of seeds developing per pod in *Robinia Pseudacacia.*

The relationship between the number of ovules and the number of seeds in a sample of 1427 pods of the black locust collected from 12 trees near Lawrence, Kansas, in the fall of 1905, is shown in Table II. The constants which interest us here are :

$$\begin{array}{ll}
x = \text{Ovules}, & y = \text{Seeds}, \\
\text{Mean } x = 12{\cdot}1794, & \text{Mean } y = 7{\cdot}6874, \\
\text{S. D. } x = 2{\cdot}2763, & \text{S. D. } y = 3{\cdot}4938, \\
V_x = 18{\cdot}690, & V_y = 45{\cdot}448, \\
 & V_x/V_y = {\cdot}4112, \\
r_{xy} = {\cdot}693 \pm {\cdot}009. & r_{xz} = {\cdot}365 \pm {\cdot}015.
\end{array}$$

Here it appears from the substantial positive value of r_{xz} that the pods with the larger numbers of ovules are relatively more capable of maturing their seeds than those with fewer. But I may add that this is not true in the case of each individual tree, so that more data are necessary before we are justified in extending this conclusion to the species at large. Evidence from another leguminous plant will be of interest in this connection.

Illustration III. Correlation between the number of ovules per pod and the number of seeds developing per pod in *Cercis Canadensis.*

Table III. is extracted from a forthcoming memoir on fertility in *Cercis Canadensis.* The correlations are :

$$\begin{array}{ll}
x = \text{Ovules}, & y = \text{Seeds}, \\
r_{xy} = {\cdot}6855 \pm {\cdot}0046. & r_{xz} = {\cdot}0070 \pm {\cdot}0087.
\end{array}$$

Here r_{xz} is so close to 0 that there seems little doubt that there is essentially no relationship between the number of ovules per pod and the capacity of the pod for maturing its seeds. This point will be discussed in detail in the memoir.

TABLE II.

Robinia Pseudacacia.

Seeds per Pod.

Ovules per Pod.

	2	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	Totals
6	—	1	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	2
7	1	1	3	2	4	—	—	—	—	—	—	—	—	—	—	—	—	—	11
8	1	5	4	8	4	6	2	—	—	—	—	—	—	—	—	—	—	—	30
9	9	9	28	15	7	19	6	10	—	—	—	—	—	—	—	—	—	—	103
10	6	33	27	38	38	23	17	12	5	—	—	—	—	—	—	—	—	—	199
11	5	25	36	39	34	41	36	12	11	6	—	—	—	—	—	—	—	—	245
12	3	16	35	33	39	32	36	19	21	15	9	—	—	—	—	—	—	—	258
13	2	8	14	17	31	28	33	23	19	20	10	10	—	—	—	—	—	—	215
14	1	1	4	4	8	10	15	12	23	14	18	9	16	—	—	—	—	—	135
15	1	1	—	3	1	3	8	6	12	18	14	15	8	9	—	—	—	—	99
16	—	—	1	—	—	—	2	3	4	9	14	7	8	9	14	—	—	—	71
17	—	—	—	2	1	—	—	1	1	3	2	—	4	4	5	9	—	—	32
18	—	—	—	—	—	—	—	—	1	3	2	1	1	1	3	2	6	—	20
19	—	—	—	—	—	—	—	—	—	—	—	2	1	—	—	1	1	2	7
Totals	29	100	152	161	168	162	155	98	97	88	69	44	38	23	22	12	7	2	1427

TABLE III.

Cercis Canadensis.

Seeds per Pod.

Ovules per Pod.

	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	Totals
2	3	31	—	—	—	—	—	—	34
3	34	176	300	—	—	—	—	—	510
4	37	226	885	1093	—	—	—	—	2241
5	17	71	310	784	1040	—	—	—	2222
6	4	14	54	153	288	375	—	—	888
7	—	1	4	9	15	33	39	—	101
8	—	—	—	1	—	1	—	2	4
Totals	95	519	1553	2040	1343	409	39	2	6000

Illustration IV. Correlation between the number of flowers per inflorescence and the number of synanthous flowers in *Spiraea Van Houtii.*

"Excess of nutrition" has been the explanation offered hundreds of times for plant abnormalities. It seems desirable, therefore, to try to correlate the presence of abnormalities with the magnitude of other organs of the plant in order to see whether they are more frequent in cases in which the organs of the individual have reached an abnormal size. An example of this kind of problem is taken from my notes on abnormalities in the inflorescence of the garden species, *Spiraea Van Houtii.*

The particular abnormality here considered is that frequently designated as synanthy in teratological literature. In the inflorescence of this species the pedicels of two or more flowers are frequently found fused for their entire length. The flowers themselves may have a more or less common receptacle, but the essential floral organs are usually so distinct that they would be counted as belonging to two flowers. The details of the abnormalities do not concern us here, and will be discussed in due time. The essential question which we wish to answer on the basis of data already tabled may be stated: Is an individual flower more (or less) likely to be abnormal if it is borne on a large* inflorescence than if it is produced on a small one?

If the chances of an individual flower being abnormal were in no way influenced by the number of flowers per inflorescence, but the chances of belonging to a synanthy were equal for all flowers, abnormalities would be distributed among the inflorescences in proportion to their number of flowers, and a correlation between the number of flowers and the number of abnormal flowers would result. Therefore this correlation coefficient will not give us the information we desire. What we need to know is the correlation between the number of flowers per inflorescence and the deviation of the number of abnormal flowers from the probable number if abnormalities were distributed among the inflorescences in proportion to the number of flowers they produce.

TABLE IV.

Spiraea Van Houtii.

Number of Flowers per Inflorescence.

Abnormal Flowers.	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*	*21*	*22*	*23*	*24*	*25*	*26*	Totals
0	1	—	5	5	8	6	9	13	16	22	17	17	12	18	21	12	14	17	9	9	3	—	234
2	—	—	1	1	2	1	9	5	3	3	5	7	9	10	7	10	6	6	4	—	1	1	91
3	—	—	—	—	—	—	1	1	2	3	7	3	3	6	10	2	1	—	3	1	1	1	45
4	—	—	—	—	—	—	—	—	—	—	—	2	1	1	3	—	—	1	—	—	—	—	8
5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	1
Totals	1	0	6	6	10	7	19	19	21	28	29	29	25	35	41	24	21	24	16	10	6	2	379

Table IV. shows the number of flowers per inflorescence and the number of flowers counted as abnormal in each inflorescence. Since the abnormality with which we are dealing is the fusion† of two flowers there can be no group of "one flower abnormal"; each abnormality was considered as two or more abnormal flowers. Our series of data is not large but it has the advantage of being taken all from one clump of plants, probably all arising from the same individual, at the Missouri Botanical Garden.

The correlations are:

x = All flowers, y = Abnormal flowers,

$r_{xy} = \cdot 121 \pm \cdot 034$. $r_{xz} = - \cdot 071 \pm \cdot 034$.

With probable errors so large as these any trustworthy conclusion is impossible. But the negative sign of the r_{xz} coefficient will be sufficient to warn one against concluding that the larger (and so presumably the more vigorous, or "better nourished") inflorescences are more apt to produce abnormal flowers. They produce *actually* more, but this is only to be expected; the question is whether they produce *relatively* more.

Finally, I would again warn the reader against any generalization from the above illustrations. They are selected to show the kind of problems to which the biometric method described may be profitably applied.

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[*] Here the only measure of the size of the inflorescence is the number of flowers which it produces.

[†] I wish to express no opinion whatever on the embryological origin of the anomaly, and the term fusion is used simply because it is the conventional and convenient term for such cases as these.

NOTICES AND BIBLIOGRAPHY.

NOTICES.

The Force of Adverse Selection among Entrants at the Extremes of Life (ages 15 to 25 and 60 or over), by EUGENE L. FISK, M.D.

A paper read before the Life Insurance Medical Directors' Association of America in which Dr Fisk re-examines, with the help of additional information, some conclusions expressed by Mr T. B. Macaulay in 1893, and comes to the conclusion that there is little adverse selection under 25, but that the group over 60 is "hypersensitive." It seems to us that this last conclusion is a natural consequence of an increasing value of the rate of mortality combined with paucity of data, and we also do not feel satisfied that Dr Fisk has done well in choosing the O^M (or with-profit policies) in preference to the O^{MN} (or without-profit policies) for his investigation as regards English experience. W. P. E.

Principles of Breeding, by E. DAVENPORT, M.Agr., LL.D. Boston, Ginn & Co. Pp. 727 + xiii.

This book is intended for the student of agriculture, and the practical breeder. Part I. deals with Variation, and discusses Morphological, Substantive, Meristic and Functional Variation; the treatment follows Bateson's "Materials," and many of Mr Davenport's illustrations are taken from that work. Part I. concludes with twenty pages on Mutation. Part II. deals with Causes of Variation, and interesting sections are devoted to Telegony, Genetic Selection, and the effect of light, food, &c., on living things. Part III. (Transmission) will probably be of most interest to readers of *Biometrika*, as it contains accounts of the methods employed in biometric research and Mendel's Law. Part IV. deals with Selection and practical problems in breeding. The book as a whole is written clearly and interestingly, and is well worth reading. W. P. E.

Die Pendulations-theorie, by Dr HEINRICH SIMROTH. Leipzig. Konrad Grethlein's Verlag, 1907. Pp. 564 + xii. Price M. 12.

A book on the geographical distribution of living things: it is entirely devoted to Reibisch's theory on the subject, and is only indirectly of interest to biometricians.

Mental and Moral Heredity in Royalty. A Statistical Study in History and Psychology, by FREDERICK ADAMS WOODS. New York (Holt), 1906. Pp. viii + 312. 104 portraits.

In spite of its somewhat tardy notice in these pages this is a book of some interest to biometricians. The work is a painstaking attempt to apply to certain material of history modern biometrical methods, with the view of reaching an adequate scientific basis for the analysis and interpretation of such material. It is suggestive of the possible usefulness of modern statistical methods in the field of history. The author's general plan in the investigation was as follows: Having as his general problem the determination of the intensity of inheritance of intellectual ability and of moral character, he proceeded to form the "ancestral tree" of twenty-two of the royal families of Europe, using Lehr's and von Behr's genealogies as primary sources. In these family trees there were 832 individuals, not counting repetitions. Each of these characters was graded (on a scale of 10 points) in respect to (*a*) intellectual ability, and (*b*) moral character. The basis of the grading was an objective treatment of statements regarding these persons found in standard historical and biographical reference works. A great deal of care was taken to make the grading accurate, and Dr Woods' decisions are probably as near to the truth as it is now possible to get. The major portion of the book is given to a summarized statement of the detailed evidence on which the grading and the dependent conclusions are based. The last two chapters are given over to the analytical treatment of the graded statistical material, and to the discussion of the conclusions to which this biometrical analysis leads. As the point of perhaps greatest interest to readers of *Biometrika*, it may be mentioned that Dr Woods holds that (*a*) there is definite evidence of the inheritance of intellectual ability and of moral character in royal families, and (*b*) that he considers the coefficients of correlation measuring this inheritance are in close accord with the expectation based on the law of ancestral inheritance.

R. P.

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Contents:—

The European Population of the United States (The Huxley Lecture), by W. Z. Ripley. The Origin of the Turkish Crescent, by W. Ridgeway. Children's Games in British New Guinea, by Capt. F. R. Barton. Introductory Notes on the Toys and Games of Elema, Papuan Gulf, by Rev. J. H. Holmes. Notes on Children's Games in British New Guinea, by A. C. Haddon. On Ten'a Folklore, by Rev. J. Jetté. A Devil Ceremony of the Peasant Sinhalese, by B. Z. Seligmann. On some Megalithic Remains in the Neighbourhood of Autun, with some observations on Lines of Standing Stones, by A. L. Lewis. Some Aspects of Spirit Worship among the Milanos of Sarawak, by A. E. Lawrence and J. H. Hewitt. Hindu Betrothal Observances in the Punjab, by H. A. Rose. Report on the Hythe Crania, by F. G. Parsons. The Kurdish Tribes of the Ottoman Empire, by Mark Sykes. Miscellanea.

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CONTENTS

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PAGE

I. Some Statistical Observations on Termites, mainly based on the work of the late G. D. Haviland. (With One Diagram in the text.) By **Ernest Warren**, D.Sc. 329

II. Note on the Skin-Colour of the Crosses between Negro and White. (With Plate I.) By **Karl Pearson**, F.R.S. 348

III. Ueber die Längenvariation der Coniferennadeln. (With 24 Diagrams in the text.) Von A. **Heyer** 354

IV. Statistical Study of Anti-Typhoid Inoculation. (With One Diagram in the text.) By G. D. **Maynard** 366

V. A Biometric Study of Phagocytosis with Special Reference to the Opsonic Index. (With 16 Diagrams in the text.) By M. **Greenwood**, Junr. and J. D. C. **White** 376

VI. A Biometric Study of the Red Blood Corpuscles of the Common Tadpole (*Rana temporaria*), from the measurements of Ernest Warren, D.Sc. (With Two Diagrams in the text.) By **Karl Pearson**, F.R.S. 402

VII. Data on Variation in the Comb of the Domestic Fowl. (With three pages of Diagrams in the text.) By R. and M. D. **Pearl** . . 420

Miscellanea. (i) Fecundity of Swine. (With Two Diagrams in the text.) By F. M. **Surface** 433

(ii) Frequency Constants of a Variable $z=f(x_1, x_2)$. By R. **Pearl** 437

(iii) The Correlation between a Variable and the Deviation of a Dependent Variable from its Probable Value. By J. **Arthur Harris** 438

Notices and Bibliography 444

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PIGMENTATION SURVEY OF SCHOOL CHILDREN IN SCOTLAND.

BY J. F. TOCHER.

This Appendix to the Report giving the absolute numbers for all the divisions, counties and districts of Scotland is issued as a Supplement to Biometrika, Vol. VI.

The cost of printing has been defrayed from a special fund presented to this Journal in memory of W. F. R. WELDON.

CONTENTS.

PAGE
I. Grand Summary. Boys and Girls, Divisions 1
II. Percentages, Boys and Girls, Divisions 2
III. Grand Summary, Boys, Divisions
„ „ Girls, „ . 2
IV. Percentages of the Classes, Boys and Girls, Divisions . . 3
V. Grand Summary, Boys, Counties . 4
VI. „ „ Girls, „ . 5
VII. Percentages, Boys, Counties 6
VIII. „ Girls, „ 7
IX. „ Chief Cities . 8
X. Values of Δ . . . 8 and 9
XI. District Summaries, Boys . 10—11
XII. „ „ Girls . 12—13
XIII. „ Percentages, Boys . 14—15
XIV. „ „ Girls . 16 and 17
XV. County and Parish Data . 18—44
XVI. Observers and Schools . 45—67

APPENDIX.

TABLE I.

Grand Summary. Boys and Girls. Divisions.

Division	HAIR					EYES				Totals
	Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark	
1	4062	781	5552	3610	238	2508	4030	4496	3209	14243
2	5214	949	6891	5139	401	3656	5592	5460	3886	18594
3	19453	4219	29396	17479	800	11039	21331	23483	15492	71345
4	20092	3822	31672	18701	954	11470	21794	24397	17580	75241
5	10429	1947	16417	10692	581	5788	12909	12695	8674	40066
6	47607	10083	83969	49732	2285	26365	58941	63868	44502	193676
7	17088	3425	26823	14735	622	9278	19303	20070	14042	62693
8	7403	1371	10722	6498	303	4031	8308	8222	5736	26297
Totals	131348	26597	211442	126584	6184	74135	152208	162691	113121	502155

TABLE II.

Percentages. Boys and Girls. Divisions.

Division	Hair					Eyes			
	Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark
1	28·52	5·48	38·98	25·35	1·67	17·61	28·29	31·57	22·53
2	28·04	5·10	37·06	27·64	2·16	19·66	30·08	29·36	20·90
3	27·27	5·91	41·20	24·50	1·12	15·47	29·90	32·91	21·72
4	26·70	5·08	42·09	24·86	1·27	15·24	28·97	32·43	23·36
5	26·03	4·86	40·97	26·69	1·45	14·45	32·22	31·68	21·65
6	24·58	5·21	43·36	25·68	1·17	13·61	30·43	32·98	22·98
7	27·26	5·46	42·79	23·50	·99	14·80	30·79	32·01	22·40
8	28·15	5·22	40·77	24·71	1·15	15·33	31·59	31·27	21·81

TABLE III.

Grand Summary. Divisions.

BOYS

Division	Hair					Eyes				Totals
	Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark	
I	1963	452	2994	1994	133	1304	2100	2467	1665	7536
II	2568	513	3666	2630	190	1841	2902	2875	1949	9567
III	9278	2251	15586	9015	403	5587	10946	12132	7868	36533
IV	9762	2003	16911	9551	506	5956	11255	12631	8891	38733
V	5128	1043	8635	5577	306	2971	6618	6657	4443	20689
VI	23891	5361	43944	24979	1216	13314	30348	33075	22654	99391
VII	8179	1803	14054	7374	322	4724	9737	10169	7102	31732
VIII	3543	736	5779	3391	136	2091	4234	4328	2932	13585
Totals	64312	14162	111569	64511	3212	37788	78140	84334	57504	257766

GIRLS

Division	Hair					Eyes				Totals
	Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark	
I	2099	329	2558	1616	105	1204	1930	2029	1544	6707
II	2646	436	3225	2509	211	1815	2690	2585	1937	9027
III	10175	1968	13810	8462	397	5452	10385	11351	7624	34812
IV	10330	1819	14761	9150	448	5514	10539	11766	8689	36508
V	5301	904	7782	5115	275	2817	6291	6038	4231	19377
VI	23716	4722	40025	24753	1069	13051	28593	30793	21848	94285
VII	8909	1622	12769	7361	300	4554	9566	9901	6940	30961
VIII	3860	635	4943	3107	167	1940	4074	3894	2804	12712
Totals	67036	12435	99873	62073	2972	36347	74068	78357	55617	244389

TABLE IV.

Percentages of the Classes for each of the Divisions.

BOYS

Division	HAIR					EYES			
	Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark
1	26·05	6·00	39·73	26·46	1·76	17·30	27·87	32·74	22·09
2	26·84	5·36	38·32	27·49	1·99	19·24	30·34	30·05	20·37
3	25·40	6·16	42·66	24·68	1·10	15·29	29·96	33·21	21·54
4	25·20	5·17	43·66	24·66	1·31	15·38	29·06	32·61	22·95
5	24·78	5·04	41·74	26·96	1·48	14·36	31·99	32·18	21·47
6	24·04	5·40	44·21	25·13	1·22	13·40	30·53	33·28	22·79
7	25·77	5·68	44·29	23·24	1·02	14·89	30·68	32·05	22·38
8	26·08	5·42	42·54	24·96	1·00	15·39	31·17	31·86	21·58
General Population	24·95	5·49	43·28	25·03	1·25	14·66	30·31	32·72	22·31

GIRLS

Division	HAIR					EYES			
	Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark
1	31·30	4·90	38·14	24·09	1·57	17·95	28·78	30·25	23·02
2	29·31	4·83	35·73	27·79	2·34	20·10	29·80	28·64	21·46
3	29·23	5·65	39·67	24·31	1·14	15·66	29·83	32·61	21·90
4	28·30	4·98	40·43	25·06	1·23	15·10	28·87	32·23	23·80
5	27·36	4·67	40·16	26·39	1·42	14·54	32·47	31·16	21·83
6	25·16	5·01	42·45	26·25	1·13	13·84	30·33	32·66	23·17
7	28·77	5·24	41·24	23·78	·97	14·71	30·90	31·98	22·41
8	30·37	5·00	38·88	24·44	1·31	15·26	32·05	30·63	22·06
General Population	27·43	5·09	40·87	25·40	1·22	14·87	30·31	32·06	22·76

TABLE V.

Grand Summary. Counties.

BOYS

County	No.	Hair					Eyes				Totals
		Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark	
Aberdeen ...	*1*	6426	1600	11189	6382	283	3844	7848	8682	5506	25880
Argyll ...	*2*	1202	257	1866	1513	77	709	1658	1573	975	4915
Ayr ...	*3*	4476	893	6977	4116	203	2748	5238	5125	3554	16665
Banff ...	*4*	1250	325	2047	1147	55	734	1335	1626	1129	4824
Berwick ...	*5*	462	72	554	362	22	238	500	435	299	1472
Bute ...	*6*	233	71	567	312	25	124	407	412	265	1208
Caithness ...	*7*	711	169	1141	744	68	361	805	976	691	2833
Clackmannan ...	*8*	493	87	844	469	6	245	627	639	388	1899
Dumbarton ...	*9*	1408	250	2188	1338	77	739	1736	1615	1171	5261
Dumfries ...	*10*	1503	262	2502	1336	43	745	1826	1941	1134	5646
Edinburgh ...	*11*	5387	1169	9217	5025	186	3044	6416	6642	4882	20984
Elgin ...	*12*	819	160	1068	650	35	573	722	836	601	2732
Fife ...	*13*	3085	618	5340	2946	156	1768	3541	4112	2724	12145
Forfar ...	*14*	3887	878	7173	3966	194	2594	4493	5177	3834	16098
Haddington ...	*15*	497	123	912	466	31	380	589	641	419	2029
Inverness ...	*16*	1293	257	1889	1389	93	938	1474	1454	1055	4921
Kincardine ...	*17*	647	141	1050	739	26	360	870	822	551	2603
Kinross ...	*18*	125	26	268	118	5	66	168	197	111	542
Kirkcudbright ...	*19*	712	176	1263	865	30	484	956	923	683	3046
Lanark ...	*20*	16455	3788	31329	17736	837	8686	21428	23751	16280	70145
Linlithgow ...	*21*	1299	311	2278	1094	58	718	1625	1664	1033	5040
Nairn ...	*22*	136	25	232	97	4	76	171	166	81	494
Orkney ...	*23*	565	101	819	496	27	353	615	691	349	2008
Peebles ...	*24*	214	60	502	198	11	121	330	326	208	985
Perth ...	*25*	2172	394	3286	2052	145	1283	2426	2506	1834	8049
Renfrew ...	*26*	2960	680	5638	3127	176	1880	3682	4199	2820	12581
Ross & Cromarty	*27*	1275	256	1777	1241	97	903	1428	1421	894	4646
Roxburgh ...	*28*	794	168	1155	639	32	492	863	782	650	2788
Selkirk ...	*29*	320	68	591	229	14	223	277	461	261	1222
Shetland ...	*30*	371	91	540	346	21	354	329	382	304	1369
Stirling ...	*31*	2285	465	4014	2414	127	1399	2817	3057	2032	9305
Sutherland ...	*32*	316	91	494	408	17	236	351	418	321	1326
Wigtown ...	*33*	534	130	859	551	31	369	589	682	465	2105
Totals ...	—	64312	14162	111569	64511	3212	37788	78140	84334	57504	257766

TABLE VI.

Grand Summary. Counties.

GIRLS

County	No.	Hair					Eyes				Totals
		Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark	
Aberdeen ...	*1*	6890	1322	9762	5972	271	3677	7293	7963	5284	24217
Argyll ...	*2*	1222	229	1676	1324	86	688	1504	1418	927	4537
Ayr ...	*3*	4687	795	6483	3837	171	2708	4911	4960	3394	15973
Banff ...	*4*	1499	336	1944	1103	46	761	1398	1622	1147	4928
Berwick ...	*5*	450	66	477	303	12	211	442	387	268	1308
Bute ...		306	64	465	330	15	140	397	401	242	1180
Caithness ...	*7*	744	117	996	647	50	357	775	798	624	2554
Clackmannan ...	*8*	485	67	706	394	4	195	561	555	345	1656
Dumbarton ...	*9*	1422	214	1940	1326	69	679	1729	1470	1093	4971
Dumfries ...	*10*	1658	251	2085	1217	63	721	1702	1750	1101	5274
Edinburgh ...	*11*	5822	1084	8656	5033	212	2957	6398	6687	4765	20807
Elgin ...	*12*	836	134	991	634	41	505	691	841	599	2636
Fife ...	*13*	3518	547	4575	2850	98	1709	3317	3813	2749	11588
Forfar ...	*14*	3922	785	6313	3840	211	2315	4188	4834	3734	15071
Haddington ...	*15*	625	108	770	496	18	353	637	595	432	2017
Inverness ...	*16*	1283	215	1630	1330	119	936	1387	1216	1038	4577
Kincardine ...	*17*	797	146	929	640	36	413	866	752	517	2548
Kinross ...	*18*	159	26	223	113	5	65	172	179	110	526
Kirkcudbright ...	*19*	783	131	1063	722	36	390	940	815	590	2735
Lanark ...	*20*	16165	3353	28447	17729	729	8685	20150	21888	15700	66423
Linlithgow ...	*21*	1459	252	1916	1103	38	721	1498	1510	1039	4768
Nairn ...	*22*	153	30	184	113	3	96	137	173	77	483
Orkney ...	*23*	573	87	672	405	21	321	536	577	324	1758
Peebles ...	*24*	244	49	466	217	8	120	315	338	211	984
Perth ...	*25*	2246	394	2944	1953	130	1230	2301	2385	1751	7667
Renfrew ...	*26*	2864	574	5095	3187	169	1658	3532	3945	2754	11889
Ross & Cromarty	*27*	1363	221	1595	1179	92	879	1303	1369	899	4450
Roxburgh ...	*28*	800	147	984	587	35	423	790	723	617	2553
Selkirk ...	*29*	309	63	484	209	12	192	276	384	225	1077
Shetland ...	*30*	378	64	408	261	18	284	272	310	263	1129
Stirling ...	*31*	2351	397	3701	2135	105	1310	2661	2749	1969	8689
Sutherland ...	*32*	404	61	482	303	16	242	347	344	333	1266
Wigtown ...	*33*	619	106	811	581	33	406	642	606	496	2150
Totals ...	—	67036	12435	99873	62073	2972	36347	74068	78357	55617	244389

TABLE VII.

Colour Percentages. Counties.

BOYS

County	No.	Hair					Eyes			
		Fair	Red	Medium	Dark	Jet Black	Pure Blue	Light	Medium	Dark
Aberdeen ...	*1*	24·83	6·18	43·24	24·66	1·10	14·85	30·32	33·55	21·28
Argyll ...	*2*	24·46	5·23	37·96	30·78	1·57	14·43	33·73	32·00	19·84
Ayr ...	*3*	26·86	5·36	41·86	24·70	1·22	16·49	31·43	30·75	21·33
Banff ...	*4*	25·91	6·74	42·43	23·78	1·14	15·22	27·67	33·71	23·40
Berwick ...	*5*	31·39	4·89	37·64	24·59	1·49	16·17	33·97	29·55	20·31
Bute ...	*6*	19·29	5·88	46·94	25·82	2·07	10·27	33·69	34·10	21·94
Caithness ...	*7*	25·10	5·97	40·27	26·26	2·40	12·74	28·42	34·45	24·39
Clackmannan ...	*8*	25·96	4·58	44·44	24·70	·32	12·90	33·02	33·65	20·43
Dumbarton ...	*9*	26·76	4·75	41·59	25·43	1·47	14·05	33·00	30·70	22·25
Dumfries ...	*10*	26·62	4·64	44·32	23·66	·76	13·20	32·34	34·38	20·08
Edinburgh ...	*11*	25·68	5·57	43·92	23·95	·88	14·51	30·58	31·65	23·26
Elgin ...	*12*	29·98	5·86	39·09	23·79	1·28	20·97	26·43	30·60	22·00
Fife ...	*13*	25·40	5·09	43·97	24·26	1·28	14·56	29·15	33·86	22·43
Forfar ...	*14*	24·15	5·45	44·56	24·64	1·20	16·11	27·91	32·16	23·82
Haddington ...	*15*	24·49	6·06	44·95	22·97	1·53	18·73	29·03	31·59	20·65
Inverness ...	*16*	26·27	5·22	38·39	28·23	1·89	19·06	29·95	29·55	21·44
Kincardine ...	*17*	24·85	5·41	40·33	28·39	1·00	13·83	33·42	31·58	21·17
Kinross ...	*18*	23·06	4·80	49·45	21·77	·92	12·18	30·99	36·35	20·48
Kirkcudbright ...	*19*	23·38	5·78	41·46	28·40	·98	15·89	31·39	30·30	22·42
Lanark ...	*20*	23·46	5·40	44·66	25·29	1·19	12·38	30·55	33·86	23·21
Linlithgow ...	*21*	25·77	6·17	45·20	21·71	1·15	14·25	32·24	33·01	20·50
Nairn ...	*22*	27·53	5·06	46·96	19·64	·81	15·39	34·61	33·60	16·40
Orkney ...	*23*	28·14	5·03	40·79	24·70	1·34	17·58	30·63	34·41	17·38
Peebles ...	*24*	21·73	6·09	50·96	20·10	1·12	12·28	33·50	33·10	21·12
Perth ...	*25*	26·99	4·89	40·83	25·49	1·80	15·94	30·14	31·13	22·79
Renfrew ...	*26*	23·53	5·41	44·81	24·85	1·40	14·94	29·27	33·38	22·41
Ross & Cromarty	*27*	27·44	5·51	38·25	26·71	2·09	19·44	30·73	30·59	19·24
Roxburgh ...	*28*	28·48	6·02	41·43	22·92	1·15	17·68	30·96	28·05	23·31
Selkirk ...	*29*	26·19	5·56	48·36	18·74	1·15	18·25	22·67	37·72	21·36
Shetland ...	*30*	27·10	6·65	39·45	25·27	1·53	25·86	24·03	27·90	22·21
Stirling ...	*31*	24·56	5·00	43·14	25·94	1·36	15·03	30·28	32·85	21·84
Sutherland ...	*32*	23·83	6·86	37·26	30·77	1·28	17·80	26·47	31·52	24·21
Wigtown ...	*33*	25·37	6·17	40·81	26·18	1·47	17·53	27·98	32·40	22·09
Total Population	—	24·95	5·49	43·28	25·03	1·25	14·66	30·31	32·72	22·31

TABLE VIII.

Colour Percentages. Counties.

GIRLS

County	No.	Hair					Eyes			
		Fair	Red	Medium	Dark	Jet Black	Pure Blue	Light	Medium	Dark
Aberdeen ...	*1*	28·41	5·46	40·31	24·66	1·12	15·18	30·12	32·88	21·82
Argyll ...	*2*	26·93	5·05	36·94	29·18	1·90	15·16	33·15	31·26	20·43
Ayr ...	*3*	29·34	4·98	40·59	24·02	1·07	16·95	30·75	31·05	21·25
Banff ...	*4*	30·42	6·82	39·45	22·38	·93	15·44	28·37	32·91	23·28
Berwick ...	*5*	34·40	5·05	36·47	23·16	·92	16·13	33·79	29·59	20·49
Bute ...	*6*	25·93	5·42	39·41	27·97	1·27	11·87	33·64	33·98	20·51
Caithness ...	*7*	29·13	4·58	39·00	25·33	1·96	13·98	30·35	31·24	24·43
Clackmannan ...	*8*	29·29	4·05	42·63	23·79	·24	11·78	33·88	33·51	20·83
Dumbarton ...	*9*	28·61	4·30	39·03	26·67	1·39	13·66	34·78	29·57	21·99
Dumfries ...	*10*	31·44	4·76	39·53	23·08	1·19	13·67	32·27	33·18	20·88
Edinburgh ...	*11*	27·98	5·21	41·60	24·19	1·02	14·21	30·75	32·14	22·90
Elgin ...	*12*	31·72	5·08	37·59	24·05	1·56	19·16	26·21	31·90	22·73
Fife ...	*13*	30·36	4·72	39·48	24·59	·85	14·75	28·62	32·91	23·72
Forfar ...	*14*	26·02	5·21	41·89	25·48	1·40	15·36	27·79	32·07	24·78
Haddington ...	*15*	30·99	5·35	38·18	24·59	·89	17·50	31·58	29·50	21·42
Inverness ...	*16*	28·03	4·70	35·61	29·06	2·60	20·45	30·30	26·57	22·68
Kincardine ...	*17*	31·28	5·73	36·46	25·12	1·41	16·21	33·99	29·51	20·29
Kinross ...	*18*	30·23	4·94	42·40	21·48	·95	12·36	32·70	34·03	20·91
Kirkcudbright ...	*19*	28·63	4·79	38·87	26·40	1·31	14·26	34·37	29·80	21·57
Lanark ...	*20*	24·33	5·05	42·83	26·69	1·10	13·07	30·34	32·95	23·64
Linlithgow ...	*21*	30·60	5·29	40·18	23·13	·80	15·12	31·42	31·67	21·79
Nairn ...	*22*	31·67	6·21	38·10	23·40	·62	19·88	28·36	35·82	15·94
Orkney ...	*23*	32·59	4·95	38·23	23·04	1·19	18·26	30·49	32·82	18·43
Peebles ...	*24*	24·80	4·98	47·36	22·05	·81	12·20	32·01	34·35	21·44
Perth ...	*25*	29·29	5·14	38·40	25·47	1·70	16·04	30·01	31·11	22·84
Renfrew ...	*26*	24·09	4·83	42·85	26·81	1·42	13·95	29·71	33·18	23·16
Ross & Cromarty	*27*	30·63	4·97	35·84	26·49	2·07	19·75	29·28	30·77	20·20
Roxburgh ...	*28*	31·34	5·76	38·54	22·99	1·37	16·57	30·94	28·32	24·17
Selkirk ...	*29*	28·69	5·85	44·94	19·41	1·11	17·83	25·63	35·65	20·89
Shetland ...	*30*	33·48	5·67	36·14	23·12	1·59	25·16	24·09	27·46	23·29
Stirling ...	*31*	27·06	4·57	42·59	24·57	1·21	15·08	30·62	31·64	22·66
Sutherland ...	*32*	31·91	4·82	38·07	23·94	1·26	19·12	27·41	27·17	26·30
Wigtown ...	*33*	28·79	4·93	37·72	27·02	1·54	18·88	29·86	28·19	23·07
Total Population	—	27·43	5·09	40·87	25·40	1·22	14·87	30·31	32·06	22·76

TABLE IX.

Colour Percentages. Chief Cities.

BOYS

	Hair					Eyes			
	Fair	Red	Medium	Dark	Jet Black	Pure Blue	Light	Medium	Dark
Aberdeen City ...	24·54	6·22	43·31	25·19	·74	12·79	30·92	33·44	22·85
„ County	25·06	6·15	43·17	25·23	1·39	16·56	29·83	33·63	19·98
Edinburgh City ...	26·31	5·39	42·98	24·32	1·00	15·11	29·81	30·47	24·61
Leith ...	23·57	5·92	45·42	24·36	·73	10·55	32·60	34·16	22·69
Edinburgh County	26·76	5·53	44·05	22·81	·85	17·66	29·79	31·11	21·44
Dundee ...	23·22	5·41	45·38	24·58	1·41	14·54	27·44	33·86	24·16
Forfar ...	25·22	5·50	43·61	24·70	·97	17·94	28·46	30·18	23·42
Glasgow ...	22·13	5·35	45·26	26·10	1·16	11·09	30·57	33·98	24·36
Govan ...	21·50	5·30	47·15	24·79	1·26	14·63	30·18	31·61	23·58
Lanark County ...	25·32	5·48	43·35	24·64	1·21	12·96	30·64	34·41	21·99

GIRLS

	Hair					Eyes			
	Fair	Red	Medium	Dark	Jet Black	Pure Blue	Light	Medium	Dark
Aberdeen City ...	27·29	5·58	40·82	25·62	·69	13·93	29·78	33·68	22·61
„ County	29·36	5·36	39·91	23·91	1·46	16·16	30·38	32·26	21·20
Edinburgh City ...	26·61	4·98	41·14	25·84	1·43	14·75	29·85	30·75	24·65
Leith ...	27·53	4·97	41·99	24·89	·62	11·04	32·88	34·53	21·55
Edinburgh County	31·01	5·91	42·03	20·34	·71	16·74	30·06	32·06	21·14
Dundee ...	24·57	5·06	42·56	26·37	1·44	14·04	27·18	34·32	24·46
Forfar ...	27·81	5·39	41·07	24·38	1·35	16·99	28·54	29·31	25·16
Glasgow ...	21·44	4·85	43·56	28·85	1·30	11·98	29·76	33·78	24·48
Govan ...	21·62	5·11	45·75	26·41	1·11	14·10	30·97	30·92	24·01
Lanark County ...	28·03	5·22	41·20	24·65	·90	13·84	30·71	32·76	22·69

TABLE X.

Values of Δ *or* $(y_s'' - y_s')/\sqrt{npq}$. *Counties.*

$$\Delta \Big/ \sqrt{1 - \left(\frac{n-1}{N-1}\right)} = (RLD) = \textit{Relative Local Difference.}$$

On comparing this table with Tables VIII. and IX. of memoir, it will be seen how far the values of Δ diverge from those of (RLD). In many cases they are fair approximations, but where n is moderately large the Δ's diverge widely from the real relative local difference or (RLD). The signs (not shown in this table) are the same as Tables VIII. and IX. of memoir.

TABLE X.

	BOYS									GIRLS								
	HAIR					EYES				HAIR					EYES			
	Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark	Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark
Aberdeen County	·32	3·45	·26	2·21	1·48	6·38	1·23	2·32	6·67	5·04	1·44	2·27	3·99	2·64	4·24	·17	·50	4·34
" City ...	1·01	3·47	·07	·39	5·00	5·73	1·44	1·67	1·42	·32	2·32	·11	·52	4·94	2·72	1·18	3·57	·37
Argyll ...	·80	·80	7·52	9·31	2·00	·47	5·22	1·07	4·16	·75	·13	5·38	5·86	4·23	·56	4·16	1·16	3·74
Ayr ...	5·69	·74	3·68	·99	·37	6·68	3·15	5·41	3·05	5·42	·65	·73	4·00	1·61	7·40	1·20	2·73	4·56
Banff ...	1·54	3·80	1·19	2·01	·69	1·09	3·98	1·46	1·82	4·70	5·52	2·03	4·87	1·77	1·13	2·97	1·28	·86
Berwick ...	5·71	1·01	4·37	·39	·85	1·64	3·05	2·59	1·84	5·65	·07	3·24	1·86	·97	1·28	2·74	1·92	1·96
Bute ...	4·55	·59	2·57	·64	2·57	4·32	2·56	1·03	·31	1·15	·52	1·02	2·03	·19	2·90	2·49	1·42	1·85
Caithness ...	·18	1·11	3·23	1·51	5·51	2·89	2·20	1·96	2·66	1·93	1·17	1·92	·08	3·45	1·27	·04	·88	2·02
Dumbarton ...	3·04	2·35	2·48	·67	1·39	1·26	4·24	3·13	·09	1·86	2·52	2·64	2·07	1·15	2·40	6·86	3·76	1·30
Dumfries ...	2·90	2·80	1·57	2·37	3·30	3·11	3·32	2·66	4·02	6·52	1·09	1·97	3·88	·10	2·45	3·10	1·75	3·26
Edinburgh County	3·06	·12	1·13	3·75	2·60	6·22	·83	2·51	1·54	5·82	2·70	1·71	8·43	3·34	3·80	·39	·01	2·80
" City ...	3·13	·45	·60	1·62	2·25	1·27	1·08	4·75	5·46	1·81	·50	·54	1·01	1·96	·34	·99	2·77	4·46
Leith ...	2·43	1·45	3·28	1·17	3·60	8·84	3·80	2·33	·69	·18	·43	1·74	·90	4·12	8·22	4·27	4·04	2·19
Elgin & Nairn ...	6·11	·61	3·42	2·46	·21	8·76	3·25	2·01	1·60	5·36	·43	3·63	1·86	1·02	6·91	4·57	·54	1·45
Fife K. & C. ...	1·22	2·54	2·33	2·25	1·14	1·39	1·53	3·10	·62	7·35	2·36	2·15	2·75	4·65	1·88	2·29	2·42	1·42
Forfar ...	·53	·06	·57	·65	2·20	8·00	3·47	4·67	2·29	·71	1·13	·33	1·93	1·04	4·89	3·16	4·84	4·71
Dundee ...	3·71	·33	3·93	·97	1·34	·31	5·82	2·26	4·14	5·85	·12	3·13	2·04	1·94	2·13	6·21	4·41	3·70
Haddington ...	·47	1·13	1·52	2·15	1·13	5·18	1·26	1·08	1·80	3·58	·54	2·46	·83	1·31	3·32	1·24	2·46	1·44
Inverness ...	2·15	·82	6·93	5·18	4·04	8·73	·55	4·75	1·47	·91	1·21	7·23	5·69	8·60	10·61	·01	7·96	·13
Kincardine ...	·11	·16	3·03	3·96	1·15	1·20	3·46	1·24	1·40	4·36	1·47	4·53	·33	·94	1·90	4·04	2·76	2·97
Kirkcudbright ...	2·01	·70	2·02	4·29	1·32	1·92	1·29	2·84	·15	1·41	·72	2·13	1·20	·51	·90	4·62	2·53	1·48
Lanark ...	1·52	·07	·24	1·58	·66	8·48	1·25	6·34	1·33	2·29	1·01	1·16	2·95	4·86	4·92	1·48	2·57	·30
Glasgow ...	11·28	1·09	6·92	4·29	1·43	17·44	·97	4·66	8·49	22·71	1·81	9·26	13·42	1·31	13·73	2·03	6·22	6·95
Govan ...	7·66	·78	7·50	·53	·05	·09	·27	2·27	2·93	12·27	·08	9·36	2·18	·83	2·03	1·36	2·31	2·80
Linlithgow ...	1·35	2·12	2·75	5·45	·63	·83	2·98	·45	3·09	4·91	·61	·96	3·60	2·61	·49	1·66	·58	1·60
Orkney ...	3·30	·91	2·25	·34	·38	3·70	·31	1·62	5·31	4·85	·27	2·26	2·28	·06	3·99	·16	·68	4·33
Perth ...	4·22	2·34	4·45	·96	4·45	3·25	·33	3·03	1·02	3·66	·19	4·40	·15	3·89	2·89	·57	1·79	·16
Renfrew ...	3·69	·42	3·47	·45	1·50	·90	2·55	1·57	·28	8·16	1·30	4·40	3·53	2·11	2·83	1·43	2·62	1·05
Ross & Cromarty	3·93	·06	6·92	2·65	5·14	9·20	·63	3·10	5·02	4·78	·38	6·82	1·68	5·23	9·15	1·49	1·85	4·07
Roxburgh ...	4·31	1·24	1·97	2·57	·49	4·51	·74	5·26	1·27	4·42	1·54	2·39	2·80	·75	2·41	·70	4·05	1·70
Selkirk & P. ...	·82	·64	5·92	6·16	·50	1·23	2·87	2·94	1·20	·61	·71	4·82	4·94	1·00	·34	1·61	2·89	1·74
Shetland ...	1·84	1·88	2·86	·21	·95	11·71	5·05	3·80	·09	4·56	·88	3·23	1·76	1·18	9·71	4·55	3·31	·43
Stirling ...	·88	2·09	·28	2·03	1·00	1·03	·08	·27	1·09	·78	2·21	3·27	1·78	·01	·54	·64	·84	·22
Sutherland ...	·94	2·19	4·43	4·83	·10	3·23	3·04	·93	1·66	3·58	·44	2·03	1·20	·18	4·25	2·45	·73	3·01
Wigtown ...	·44	1·38	2·29	1·21	·92	3·72	2·33	·31	·24	1·41	·34	2·97	1·73	1·38	5·23	·45	3·85	·34

TABLE XI.

District Totals.

BOYS

Number of District	Hair					Eyes				Totals
	Fair	Red	Medium	Dark	Jet Black	Pure Blue	Light	Medium	Dark	
I	592	119	849	504	36	281	594	719	506	2100
II	464	111	557	308	22	378	305	401	378	1462
III	533	136	1153	555	25	345	660	881	516	2402
IV	391	66	668	442	22	240	508	478	363	1589
V	963	174	1394	883	53	444	1084	1178	761	3467
VI	931	214	1547	904	50	369	1171	1294	812	3646
VII	536	103	855	557	24	258	611	781	425	2075
VIII	260	60	365	205	13	109	361	278	155	903
IX	765	127	1063	639	29	293	912	867	551	2623
X	286	63	655	272	7	163	389	484	247	1283
XI	837	190	1826	936	44	474	1134	1397	828	3833
XII	664	170	1171	781	18	317	960	936	591	2804
XIII	9161	2227	18999	10658	481	4964	12679	13887	9996	41526
XIV	650	154	1222	782	27	416	837	892	690	2835
XV	360	102	772	354	18	168	536	599	303	1606
XVI	360	79	569	374	7	242	362	491	294	1389
XVII	388	87	656	404	19	226	533	485	310	1554
XVIII	626	128	1069	550	62	417	659	783	576	2435
XIX	224	66	485	232	10	82	352	385	198	1017
XX	79	9	81	56	3	18	88	65	57	228
XXI	282	50	497	244	16	164	322	385	218	1089
XXII	157	32	311	190	17	105	204	220	178	707
XXIII	55	10	152	56	5	31	81	118	48	278
XXIV	760	198	1749	946	47	546	1073	1205	876	3700
XXV	340	88	507	368	18	169	447	392	313	1321
XXVI	673	115	1029	560	30	408	660	831	508	2407
XXVII	522	127	1002	522	21	309	754	672	459	2194
XXVIII	1044	192	1451	837	68	612	1157	1049	774	3592
XXIX	359	81	592	388	11	304	414	391	322	1431
XXX	833	143	1178	600	22	501	954	811	510	2776
XXXI	515	98	905	652	24	285	639	738	532	2194
XXXII	400	101	657	431	22	318	430	515	348	1611
XXXIII	173	41	300	231	11	105	215	255	181	756
XXXIV	601	154	1042	711	22	402	807	750	571	2530
XXXV	421	88	727	378	16	162	562	601	305	1630
XXXVI	479	97	725	453	24	250	619	552	357	1778
XXXVII	819	130	1382	698	13	493	892	1036	621	3042
XXXVIII	347	61	432	241	13	156	377	327	234	1094
XXXIX	466	108	736	412	23	347	497	470	431	1745
XL	307	68	578	224	14	217	268	452	254	1191
XLI	214	60	502	198	11	121	330	326	208	985
XLII	453	68	539	350	18	234	487	418	289	1428
XLIII	497	123	912	466	31	380	589	641	419	2029
XLIV	2584	529	4220	2388	98	1484	2927	2992	2416	9819
XLV	1365	343	2630	1411	42	611	1888	1978	1314	5791
XLVI	643	137	1024	531	22	378	753	733	493	2357
XLVII	795	160	1343	695	24	571	858	939	649	3017
XLVIII	822	219	1577	776	42	395	1140	1203	698	3436
XLIX	477	92	701	318	16	323	485	461	335	1604
L	207	43	412	280	19	141	243	355	222	961
LI	523	94	868	487	9	262	660	655	404	1981
LII	506	69	643	456	19	257	538	492	406	1693
LIII	588	115	1072	540	13	321	751	770	486	2328
LIV	338	73	642	309	19	243	374	466	298	1381
LV	454	86	726	414	36	256	538	526	396	1716

TABLE XI.—(*continued*).

District Totals.

BOYS

Number of District	Hair					Eyes				Totals
	Fair	Red	Medium	Dark	Jet Black	Pure Blue	Light	Medium	Dark	
LVI	254	45	364	218	17	140	261	276	221	898
LVII	863	213	1749	847	38	476	1004	1424	806	3710
LVIII	283	68	560	325	15	187	390	434	240	1251
LIX	528	78	676	455	33	328	602	467	373	1770
LX	307	78	699	340	23	150	453	502	342	1447
LXI	471	96	737	477	35	356	498	577	385	1816
LXII	490	113	960	595	34	307	611	814	460	2192
LXIII	316	51	587	341	16	212	392	376	331	1311
LXIV	302	53	528	353	5	175	342	361	363	1241
LXV	435	114	911	469	22	380	576	570	425	1951
LXVI	2038	476	3964	2152	122	1270	2409	2950	2123	8752
LXVII	250	51	338	246	17	114	272	314	202	902
LXVIII	401	81	535	328	23	316	326	392	334	1368
LXIX	645	109	1042	579	20	278	710	820	587	2395
LXX	358	62	428	301	26	231	296	349	299	1175
LXXI	329	53	470	328	34	199	435	317	263	1214
LXXII	364	68	509	347	8	178	433	394	291	1296
LXXIII	271	65	531	267	10	191	360	355	238	1144
LXXIV	296	66	447	346	14	171	377	365	256	1169
LXXV	308	60	524	269	12	212	334	384	243	1173
LXXVI	76	12	145	86	12	66	83	106	76	331
LXXVII	2868	727	5061	2943	86	1494	3613	3908	2670	11685
LXXVIII	480	105	748	402	28	232	491	672	368	1763
LXXIX	369	107	714	447	17	301	532	516	305	1654
LXXX	703	176	1025	598	42	495	744	822	483	2544
LXXXI	406	102	817	451	27	218	506	635	444	1803
LXXXII	416	103	789	402	17	262	575	561	329	1727
LXXXIII	511	104	791	445	36	366	548	639	334	1887
LXXXIV	332	114	708	373	14	281	471	493	296	1541
LXXXV	631	166	1201	599	17	304	738	969	603	2614
LXXXVI	271	66	465	240	16	186	290	346	236	1058
LXXXVII	530	116	767	485	14	304	512	639	457	1912
LXXXVIII	537	84	578	378	18	371	427	421	376	1595
LXXXIX	317	75	561	245	13	161	365	459	226	1211
XC	295	78	448	299	23	272	334	296	241	1143
XCI	298	62	301	254	28	218	271	256	198	943
XCII	346	90	611	393	28	235	380	544	309	1468
XCIII	450	78	574	431	19	329	479	444	300	1552
XCIV	85	21	136	96	9	111	112	71	53	347
XCV	236	61	396	324	31	148	341	359	200	1048
XCVI	255	76	366	316	9	217	250	313	242	1022
XCVII	489	104	605	454	53	206	460	614	425	1705
XCVIII	222	65	536	290	15	155	345	362	266	1128
XCIX	466	97	599	521	40	305	552	482	384	1723
C	303	60	364	330	28	185	367	318	215	1085
CI	288	69	475	379	17	143	443	399	243	1228
CII	261	42	384	391	13	130	466	294	201	1091
CIII	343	67	590	404	22	254	371	509	292	1426
CIV	351	111	786	441	34	197	539	603	384	1723
CV	676	111	915	644	38	412	750	662	560	2384
CVI	288	35	433	226	10	86	323	379	204	992
CVII	145	17	219	163	7	105	173	157	116	551
CVIII	544	91	814	479	33	391	598	556	416	1961
CIX	565	101	819	496	27	353	615	691	349	2008
CX	371	91	540	346	21	354	329	382	304	1369

TABLE XII.

District Totals.

GIRLS

Number of District	Hair					Eyes				Totals
	Fair	Red	Medium	Dark	Jet Black	Pure Blue	Light	Medium	Dark	
I	544	97	677	451	14	269	512	600	402	1783
II	459	83	525	280	16	289	387	325	362	1363
III	628	118	1014	522	20	348	675	831	448	2302
IV	412	89	667	416	19	307	419	496	381	1603
V	1003	177	1229	819	37	431	1029	1056	749	3265
VI	978	165	1384	794	30	366	1129	1126	730	3351
VII	551	110	779	470	15	254	562	681	428	1925
VIII	293	51	375	196	13	176	293	295	164	928
IX	642	102	956	607	23	288	809	677	556	2330
X	364	60	549	267	4	162	394	421	267	1244
XI	897	196	1515	899	37	419	1015	1282	828	3544
XII	677	164	1074	636	35	320	949	804	563	2636
XIII	8648	1952	17529	11151	484	4977	11982	13134	9671	39764
XIV	701	114	1166	755	23	421	849	838	651	2759
XV	326	82	693	323	11	145	473	507	310	1435
XVI	361	51	468	357	12	127	381	462	279	1249
XVII	358	69	604	402	16	162	473	495	319	1449
XVIII	575	121	977	605	56	435	636	705	558	2334
XIX	223	63	480	255	15	92	352	359	233	1036
XX	83	8	90	60	5	11	90	64	81	246
XXI	231	41	425	235	12	168	235	329	212	944
XXII	184	32	290	169	9	87	227	202	168	684
XXIII	70	12	126	93	7	39	99	102	68	308
XXIV	762	178	1569	984	32	504	1039	1177	805	3525
XXV	332	59	511	333	6	177	425	364	275	1241
XXVI	770	128	933	497	26	430	671	782	471	2354
XXVII	470	89	977	507	15	274	700	637	447	2058
XXVIII	1049	163	1296	827	35	605	1092	947	726	3370
XXIX	444	66	608	335	24	263	348	552	314	1477
XXX	811	147	1060	590	31	489	869	764	517	2639
XXXI	570	102	810	527	26	311	574	665	485	2035
XXXII	457	89	582	449	26	331	447	466	359	1603
XXXIII	217	32	317	213	8	130	240	220	197	787
XXXIV	640	111	875	597	30	335	777	668	473	2253
XXXV	385	62	561	359	14	153	480	460	288	1381
XXXVI	595	86	636	403	26	212	602	585	347	1746
XXXVII	948	140	1173	650	29	482	892	938	628	2940
XXXVIII	333	55	391	221	13	147	331	285	250	1013
XXXIX	478	93	603	376	22	280	463	447	382	1572
XL	302	62	477	205	12	188	269	381	220	1058
XLI	244	49	466	217	8	120	315	338	211	984
XLII	443	64	467	291	12	208	437	376	256	1277
XLIII	625	108	770	496	18	353	637	595	432	2017
XLIV	2593	485	4008	2518	139	1437	2908	2996	2402	9743
XLV	1602	289	2443	1448	36	642	1913	2009	1254	5818
XLVI	684	138	940	493	14	348	694	736	491	2269
XLVII	943	172	1265	574	23	530	883	946	618	2977
XLVIII	943	186	1344	785	24	440	1005	1130	707	3282
XLIX	516	66	572	318	14	281	493	380	332	1486
L	254	41	372	223	8	90	255	314	239	898
LI	516	73	735	413	7	218	588	578	360	1744
LII	601	55	585	377	11	301	472	456	400	1629
LIII	691	121	975	507	12	318	745	770	473	2306
LIV	413	65	571	277	11	222	372	443	300	1337
LV	532	89	608	430	22	244	518	478	441	1681

TABLE XII.—(*continued*).

District Totals.

GIRLS

Number of District	Hair					Eyes				Totals
	Fair	Red	Medium	Dark	Jet Black	Pure Blue	Light	Medium	Dark	
LVI	263	48	313	220	19	133	247	260	223	863
LVII	923	154	1474	829	20	466	880	1271	783	3400
LVIII	336	73	505	325	16	186	394	416	259	1255
LIX	521	79	648	417	37	306	629	426	341	1702
LX	374	60	695	357	12	165	442	515	376	1498
LXI	510	78	585	394	24	315	451	455	370	1591
LXII	519	86	900	525	41	316	553	751	451	2071
LXIII	271	49	510	337	11	182	350	352	294	1178
LXIV	280	63	505	372	14	138	360	370	366	1234
LXV	426	94	809	408	21	322	485	523	428	1758
LXVI	2084	424	3560	2229	120	1178	2295	2880	2064	8417
LXVII	242	47	289	206	16	130	234	244	192	800
LXVIII	432	70	500	296	22	265	323	394	338	1320
LXIX	643	113	988	539	14	296	657	807	537	2297
LXX	360	62	306	268	30	227	256	275	268	1026
LXXI	325	52	411	321	21	190	397	311	232	1130
LXXII	374	48	494	282	16	186	386	340	302	1214
LXXIII	299	62	450	236	11	183	364	278	233	1058
LXXIV	375	79	400	294	13	186	392	365	218	1161
LXXV	307	62	360	236	18	172	270	309	232	983
LXXVI	92	15	99	77	10	67	74	92	60	293
LXXVII	2903	594	4342	2725	73	1482	3168	3582	2405	10637
LXXVIII	520	101	714	411	22	231	522	659	356	1768
LXXIX	457	84	582	411	21	257	544	439	315	1555
LXXX	754	132	807	535	34	446	721	670	425	2262
LXXXI	439	84	706	474	26	234	471	583	441	1729
LXXXII	509	80	684	396	18	233	533	569	352	1687
LXXXIII	569	101	704	413	31	324	538	586	370	1818
LXXXIV	364	63	648	313	27	240	451	432	292	1415
LXXXV	728	170	1139	597	15	276	772	952	649	2649
LXXXVI	341	79	457	251	17	234	304	354	253	1145
LXXXVII	634	112	753	421	20	345	538	619	438	1940
LXXXVIII	509	79	540	364	26	336	374	442	366	1518
LXXXIX	319	58	468	259	7	158	311	413	229	1111
XC	385	92	422	279	21	271	325	353	250	1199
XCI	327	57	275	243	31	216	256	251	210	933
XCII	350	65	545	411	17	254	385	448	301	1388
XCIII	507	64	574	405	33	335	494	457	297	1583
XCIV	93	35	91	104	7	98	117	71	44	330
XCV	270	41	380	301	19	140	297	332	242	1011
XCVI	349	52	360	227	11	226	290	245	238	999
XCVII	465	71	502	386	38	211	434	472	345	1462
XCVIII	279	46	494	261	12	146	341	326	279	1092
XCIX	484	61	494	481	33	306	473	410	364	1553
C	284	53	296	316	36	167	313	301	204	985
CI	298	56	430	341	16	147	389	381	224	1141
CII	258	54	337	291	14	134	372	258	190	954
CIII	387	59	535	375	32	232	414	439	303	1388
CIV	412	90	671	442	26	200	529	554	358	1641
CV	660	73	765	657	34	363	733	600	493	2189
CVI	294	29	388	213	3	68	330	328	201	927
CVII	104	31	205	122	12	99	168	99	108	474
CVIII	506	90	692	462	38	368	490	537	393	1788
CIX	573	87	672	405	21	321	536	577	324	1758
CX	378	64	408	261	18	284	272	310	263	1129

TABLE XIII.

District Percentages.

BOYS

Number of District	Hair					Eyes			
	Fair	Red	Medium	Dark	Jet Black	Pure Blue	Light	Medium	Dark
I	28·19	5·67	40·43	24·00	1·71	13·38	28·29	34·24	24·09
II	31·74	7·59	38·10	21·07	1·50	25·86	20·86	27·43	25·85
III	22·19	5·66	48·00	23·11	1·04	14·36	27·48	36·68	21·48
IV	24·61	4·15	42·04	27·82	1·38	15·10	31·97	30·08	22·85
V	27·77	5·02	40·21	25·47	1·53	12·81	31·26	33·98	21·95
VI	25·54	5·87	42·43	24·79	1·37	10·12	32·12	35·49	22·27
VII	25·83	4·96	41·21	26·84	1·16	12·43	29·45	37·64	20·48
VIII	28·79	6·65	40·42	22·70	1·44	12·07	39·98	30·79	17·16
IX	29·16	4·84	40·53	24·36	1·11	11·17	34·77	33·05	21·01
X	22·29	4·91	51·05	21·20	·55	12·71	30·32	37·72	19·25
XI	21·83	4·96	47·64	24·42	1·15	12·37	29·59	36·44	21·60
XII	23·68	6·06	41·76	27·86	·64	11·30	34·24	33·38	21·08
XIII	22·07	5·36	45·75	25·66	1·16	11·96	30·53	33·44	24·07
XIV	22·93	5·43	43·11	27·58	·95	14·67	29·53	31·46	24·34
XV	22·42	6·35	48·07	22·04	1·12	10·46	33·37	37·30	18·87
XVI	25·92	5·69	40·96	26·93	·50	17·42	26·06	35·35	21·17
XVII	24·97	5·60	42·20	26·00	1·23	14·54	34·30	31·21	19·95
XVIII	25·71	5·26	43·90	22·59	2·54	17·13	27·06	32·16	23·65
XIX	22·03	6·49	47·69	22·81	·98	8·06	34·61	37·86	19·47
XX	34·65	3·95	35·52	24·56	1·32	7·89	38·60	28·51	25·00
XXI	25·89	4·59	45·64	22·41	1·47	15·06	29·57	35·35	20·02
XXII	22·21	4·53	43·99	26·87	2·40	14·85	28·85	31·12	25·18
XXIII	19·78	3·60	54·68	20·14	1·80	11·15	29·14	42·44	17·27
XXIV	20·54	5·35	47·27	25·57	1·27	14·76	29·00	32·57	23·67
XXV	25·74	6·66	38·38	27·86	1·36	12·79	33·84	29·68	23·69
XXVI	27·96	4·78	42·75	23·26	1·25	16·95	27·42	34·52	21·11
XXVII	23·79	5·79	45·67	23·79	·96	14·08	34·37	30·63	20·92
XXVIII	29·07	5·35	40·39	23·30	1·89	17·04	32·21	29·20	21·55
XXIX	25·09	5·66	41·37	27·11	·77	21·25	28·93	27·32	22·50
XXX	30·01	5·15	42·44	21·61	·79	18·05	34·37	29·21	18·37
XXXI	23·47	4·47	41·25	29·72	1·09	12·99	29·12	33·64	24·25
XXXII	24·83	6·27	40·78	26·75	1·37	19·74	26·69	31·97	21·60
XXXIII	22·88	5·42	39·68	30·56	1·46	13·89	28·44	33·73	23·94
XXXIV	23·76	6·09	41·18	28·10	·87	15·89	31·90	29·64	22·57
XXXV	25·83	5·40	44·60	23·19	·98	9·94	34·48	36·87	18·71
XXXVI	26·94	5·45	40·78	25·48	1·35	14·06	34·81	31·05	20·08
XXXVII	26·92	4·27	45·43	22·95	·43	16·21	29·32	34·06	20·41
XXXVIII	31·72	5·57	39·49	22·03	1·19	14·26	34·46	29·89	21·39
XXXIX	26·70	6·19	42·18	23·61	1·32	19·89	28·48	26·93	24·70
XL	25·78	5·71	48·53	18·81	1·17	18·22	22·50	37·95	21·33
XLI	21·73	6·09	50·96	20·10	1·12	12·28	33·50	33·10	21·12
XLII	31·72	4·76	37·75	24·51	1·26	16·39	34·10	29·27	20·24
XLIII	24·49	6·06	44·95	22·97	1·53	18·73	29·03	31·59	20·65
XLIV	26·31	5·39	42·98	24·32	1·00	15·11	29·81	30·47	24·61
XLV	23·57	5·92	45·42	24·37	·72	10·55	32·60	34·16	22·69
XLVI	27·28	5·81	43·45	22·53	·93	16·04	31·94	31·10	20·92
XLVII	26·35	5·30	44·52	23·04	·79	18·93	28·44	31·12	21·51
XLVIII	23·92	6·37	45·90	22·59	1·22	11·50	33·18	35·01	20·31
XLIX	29·74	5·74	43·70	19·82	1·00	20·14	30·24	28·74	20·88
L	21·54	4·47	42·87	29·14	1·98	14·67	25·29	36·94	23·10
LI	26·40	4·75	43·82	24·58	·45	13·23	33·32	33·06	20·39
LII	29·89	4·08	37·98	26·93	1·12	15·18	31·78	29·06	23·98
LIII	25·26	4·94	46·05	23·19	·56	13·79	32·26	33·08	20·87
LIV	24·47	5·29	46·49	22·37	1·38	17·60	27·08	33·74	21·58
LV	26·46	5·01	42·31	24·12	2·10	14·92	31·35	30·65	23·08

TABLE XIII.—(*continued*).

District Percentages.

BOYS

Number of District	Hair					Eyes			
	Fair	Red	Medium	Dark	Jet Black	Pure Blue	Light	Medium	Dark
LVI	28·29	5·01	40·53	24·28	1·89	15·59	29·06	30·74	24·61
LVII	23·26	5·74	47·14	22·83	1·03	12·83	27·06	38·38	21·73
LVIII	22·62	5·43	44·77	25·98	1·20	14·95	31·17	34·69	19·19
LIX	29·83	4·41	38·19	25·71	1·86	18·53	34·01	26·39	21·07
LX	21·21	5·39	48·31	23·50	1·59	10·37	31·31	34·69	23·63
LXI	25·94	5·28	40·58	26·27	1·93	19·61	27·42	31·77	21·20
LXII	22·35	5·16	43·80	27·14	1·55	14·01	27·87	37·13	20·99
LXIII	24·10	3·89	44·78	26·01	1·22	16·17	29·90	28·68	25·25
LXIV	24·33	4·27	42·55	28·45	·40	14·10	27·56	29·09	29·25
LXV	22·30	5·84	46·69	24·04	1·13	19·48	29·52	29·22	21·78
LXVI	23·29	5·44	45·29	24·59	1·39	14·51	27·52	33·71	24·26
LXVII	27·73	5·64	37·47	27·27	1·89	12·64	30·16	34·81	22·39
LXVIII	29·31	5·92	39·11	23·98	1·68	23·10	23·83	28·65	24·42
LXIX	26·93	4·55	43·51	24·18	·83	11·61	29·64	34·24	24·51
LXX	30·47	5·28	36·42	25·62	2·21	19·66	25·19	29·70	25·45
LXXI	27·10	4·37	38·71	27·02	2·80	16·39	35·83	26·11	21·67
LXXII	28·09	5·25	39·27	26·77	·62	13·74	33·41	30·40	22·45
LXXIII	23·69	5·68	46·42	23·34	·87	16·70	31·47	31·03	20·80
LXXIV	25·32	5·64	38·24	29·60	1·20	14·63	32·25	31·22	21·90
LXXV	26·26	5·12	44·67	22·93	1·02	18·07	28·48	32·74	20·71
LXXVI	22·96	3·62	43·81	25·98	3·63	19·94	25·08	32·02	22·96
LXXVII	24·54	6·22	43·31	25·19	·74	12·79	30·92	33·44	22·85
LXXVIII	27·23	5·95	42·43	22·80	1·59	13·16	27·85	38·12	20·87
LXXIX	22·31	6·47	43·17	27·02	1·03	18·20	32·16	31·20	18·44
LXXX	27·63	6·92	40·29	23·51	1·65	19·46	29·24	32·31	18·99
LXXXI	22·52	5·66	45·31	25·01	1·50	12·09	28·06	35·22	24·63
LXXXII	24·09	5·96	45·69	23·28	·98	15·17	33·30	32·48	19·05
LXXXIII	27·08	5·51	41·92	23·58	1·91	19·40	29·04	33·86	17·70
LXXXIV	21·54	7·40	45·94	24·21	·91	18·24	30·56	31·99	19·21
LXXXV	24·14	6·35	45·94	22·92	·65	11·63	28·23	37·07	23·07
LXXXVI	25·61	6·24	43·95	22·69	1·51	17·58	27·41	32·70	22·31
LXXXVII	27·72	6·07	40·11	25·37	·73	15·90	26·78	33·42	23·90
LXXXVIII	33·67	5·26	36·24	23·70	1·13	23·26	26·77	26·40	23·57
LXXXIX	26·18	6·19	46·33	20·23	1·07	13·30	30·14	37·90	18·66
XC	25·81	6·82	39·20	26·16	2·01	23·80	29·22	25·90	21·08
XCI	31·60	6·58	31·92	26·93	2·97	23·12	28·74	27·15	20·99
XCII	23·57	6·13	41·62	26·77	1·91	16·01	25·88	37·06	21·05
XCIII	29·00	5·03	36·98	27·77	1·22	21·20	30·86	28·61	19·33
XCIV	24·50	6·05	39·19	27·67	2·59	31·98	32·29	20·46	15·27
XCV	22·52	5·82	37·78	30·92	2·96	14·12	32·54	34·26	19·08
XCVI	24·95	7·44	35·81	30·92	·88	21·23	24·46	30·63	23·68
XCVII	28·68	6·10	35·48	26·63	3·11	12·08	26·98	36·01	24·93
XCVIII	19·68	5·76	47·52	25·71	1·33	13·74	30·59	32·09	23·58
XCIX	27·04	5·63	34·77	30·24	2·32	17·70	32·04	27·97	22·29
C	27·93	5·53	33·55	30·41	2·58	17·05	33·82	29·31	19·82
CI	23·45	5·62	38·68	30·86	1·39	11·65	36·07	32·49	19·79
CII	23·92	3·85	35·20	35·84	1·19	11·92	42·71	26·95	18·42
CIII	24·05	4·70	41·38	28·33	1·54	17·81	26·02	35·69	20·48
CIV	20·37	6·44	45·62	25·60	1·97	11·43	31·28	35·00	22·29
CV	28·36	4·66	38·38	27·01	1·59	17·28	31·46	27·77	23·49
CVI	29·03	3·53	43·65	22·78	1·01	8·67	32·56	38·21	20·56
CVII	26·32	3·08	39·75	29·58	1·27	19·06	31·40	28·49	21·05
CVIII	27·74	4·64	41·51	24·43	1·68	19·94	30·50	28·35	21·21
CIX	28·14	5·03	40·79	24·70	1·34	17·58	30·63	34·41	17·38
CX	27·10	6·65	39·45	25·27	1·53	25·86	24·03	27·90	22·21

TABLE XIV.

District Percentages.

GIRLS

Number of District	Hair					Eyes			
	Fair	Red	Medium	Dark	Jet Black	Pure Blue	Light	Medium	Dark
I	30·51	5·44	37·97	25·30	·78	15·09	28·72	33·65	22·54
II	33·68	6·09	38·52	20·54	1·17	21·20	28·39	23·85	26·56
III	27·28	5·12	44·05	22·68	·87	15·12	29·32	36·10	19·46
IV	25·70	5·55	41·61	25·95	1·19	19·15	26·14	30·94	23·77
V	30·72	5·42	37·64	25·09	1·13	13·20	31·52	32·34	22·94
VI	29·19	4·92	41·30	23·70	·89	10·92	33·69	33·60	21·79
VII	28·62	5·71	40·47	24·42	·78	13·20	29·19	35·38	22·23
VIII	31·57	5·50	40·41	21·12	1·40	18·97	31·57	31·79	17·67
IX	27·55	4·38	41·03	26·05	·99	12·36	34·72	29·06	23·86
X	29·26	4·82	44·13	21·46	·32	13·02	31·67	33·84	21·46
XI	25·31	5·53	42·75	25·37	1·04	11·82	28·64	36·18	23·36
XII	25·68	6·22	40·74	26·03	1·33	12·14	36·00	30·50	21·36
XIII	21·75	4·91	44·08	28·04	1·22	12·52	30·13	33·03	24·32
XIV	25·41	4·13	42·26	27·37	·83	15·26	30·77	30·37	23·60
XV	22·72	5·71	48·29	22·51	·77	10·11	32·96	35·33	21·60
XVI	28·91	4·08	37·47	28·58	·96	10·17	30·50	36·99	22·34
XVII	24·71	4·76	41·68	27·74	1·11	11·18	32·64	34·16	22·02
XVIII	24·64	5·18	41·86	25·92	2·40	18·64	27·25	30·20	23·91
XIX	21·53	6·08	46·33	24·61	1·45	8·88	33·98	34·65	22·49
XX	33·74	3·25	36·59	24·39	2·03	4·47	36·58	26·02	32·93
XXI	24·47	4·34	45·02	24·90	1·27	17·80	24·89	34·85	22·46
XXII	26·90	4·68	42·40	24·71	1·31	12·72	33·19	29·53	24·56
XXIII	22·73	3·90	40·91	30·19	2·27	12·66	32·14	33·12	22·08
XXIV	21·62	5·05	44·51	27·91	·91	14·30	29·47	33·39	22·84
XXV	26·75	4·76	41·18	26·83	·48	14·26	34·25	29·33	22·16
XXVI	32·71	5·44	39·63	21·11	1·11	18·27	28·50	33·22	20·01
XXVII	22·84	4·33	47·47	24·63	·73	13·32	34·01	30·95	21·72
XXVIII	31·13	4·84	38·45	24·54	1·04	17·95	32·41	28·10	21·54
XXIX	30·06	4·47	41·16	22·68	1·63	17·81	23·56	37·37	21·26
XXX	30·73	5·57	40·17	22·36	1·17	18·53	32·93	28·95	19·59
XXXI	28·01	5·01	39·80	25·90	1·28	15·28	28·21	32·68	23·83
XXXII	28·51	5·55	36·31	28·01	1·62	20·65	27·88	29·07	22·40
XXXIII	27·57	4·07	40·28	27·06	1·02	16·52	30·50	27·95	25·03
XXXIV	28·41	4·93	38·83	26·50	1·33	14·87	34·49	29·65	20·99
XXXV	27·88	4·49	40·62	26·00	1·01	11·08	34·76	33·31	20·85
XXXVI	34·08	4·93	36·42	23·08	1·49	12·14	34·48	33·51	19·87
XXXVII	32·24	4·76	39·90	22·11	·99	16·39	30·34	31·91	21·36
XXXVIII	32·87	5·43	38·60	21·82	1·28	14·51	32·68	28·13	24·68
XXXIX	30·41	5·91	38·36	23·92	1·40	17·81	29·45	28·44	24·30
XL	28·54	5·86	45·09	19·38	1·13	17·77	25·43	36·01	20·79
XLI	24·80	4·98	47·36	22·05	·81	12·20	32·01	34·35	21·44
XLII	34·69	5·01	36·57	22·79	·94	16·29	34·22	29·44	20·05
XLIII	30·99	5·35	38·18	24·59	·89	17·50	31·58	29·50	21·42
XLIV	26·61	4·98	41·14	25·84	1·43	14·75	29·85	30·75	24·65
XLV	27·53	4·97	41·99	24·89	·62	11·04	32·88	34·53	21·55
XLVI	30·14	6·08	41·43	21·73	·62	15·34	30·58	32·44	21·64
XLVII	31·68	5·78	42·49	19·28	·77	17·80	29·66	31·78	20·76
XLVIII	28·73	5·67	40·95	23·92	·73	13·41	30·62	34·43	21·54
XLIX	34·73	4·44	38·49	21·40	·94	18·91	33·18	25·57	22·34
L	28·29	4·57	41·42	24·83	·89	10·02	28·40	34·97	26·61
LI	29·59	4·19	42·14	23·68	·40	12·50	33·72	33·14	20·64
LII	36·89	3·38	35·91	23·14	·68	18·48	28·98	27·99	24·55
LIII	29·96	5·25	42·28	21·99	·52	13·79	32·31	33·39	20·51
LIV	30·89	4·86	42·71	20·72	·82	16·61	27·82	33·13	22·44
LV	31·65	5·29	36·17	25·58	1·31	14·51	30·82	28·44	26·23

TABLE XIV.—(*continued*).

District Percentages.

GIRLS

Number of District	Hair					Eyes			
	Fair	Red	Medium	Dark	Jet Black	Pure Blue	Light	Medium	Dark
LVI	30·48	5·56	36·27	25·49	2·20	15·41	28·62	30·13	25·84
LVII	27·15	4·53	43·35	24·38	·59	13·71	25·88	37·38	23·03
LVIII	26·77	5·82	40·24	25·90	1·27	14·82	31·39	33·15	20·64
LIX	30·61	4·64	38·07	24·50	2·18	17·98	36·96	25·03	20·03
LX	24·97	4·01	46·39	23·83	·80	11·01	29·51	34·38	25·10
LXI	32·06	4·90	36·77	24·76	1·51	19·80	28·35	28·60	23·25
LXII	25·06	4·15	43·46	25·35	1·98	15·26	26·70	36·26	21·78
LXIII	23·01	4·16	43·29	28·61	·93	15·45	29·71	29·88	24·96
LXIV	22·69	5·11	40·92	30·15	1·13	11·18	29·17	29·99	29·66
LXV	24·23	5·35	46·02	23·21	1·19	18·32	27·59	29·75	24·34
LXVI	24·76	5·04	42·29	26·48	1·43	13·99	27·27	34·22	24·52
LXVII	30·25	5·87	36·13	25·75	2·00	16·25	29·25	30·50	24·00
LXVIII	32·73	5·30	37·88	22·42	1·67	20·08	24·47	29·85	25·60
LXIX	27·99	4·92	43·01	23·47	·61	12·89	28·60	35·13	23·38
LXX	35·09	6·04	29·83	26·12	2·92	22·13	24·95	26·80	26·12
LXXI	28·76	4·60	36·37	28·41	1·86	16·82	35·13	27·52	20·53
LXXII	30·81	3·95	40·69	23·23	1·32	15·32	31·80	28·00	24·88
LXXIII	28·26	5·86	42·53	22·31	1·04	17·30	34·40	26·28	22·02
LXXIV	32·30	6·81	34·45	25·32	1·12	16·02	33·76	31·44	18·78
LXXV	31·23	6·31	36·62	24·01	1·83	17·50	27·47	31·43	23·60
LXXVI	31·40	5·12	33·79	26·28	3·41	22·87	25·25	31·40	20·48
LXXVII	27·29	5·58	40·82	25·62	·69	13·93	29·78	33·68	22·61
LXXVIII	29·41	5·71	40·39	23·25	1·24	13·06	29·53	37·27	20·14
LXXIX	29·39	5·40	37·43	26·43	1·35	16·53	34·98	28·23	20·26
LXXX	33·33	5·84	35·68	23·65	1·50	19·72	31·87	29·62	18·79
LXXXI	25·39	4·86	40·83	27·42	1·50	13·53	27·24	33·72	25·51
LXXXII	30·17	4·74	40·55	23·47	1·07	13·81	31·59	33·73	20·87
LXXXIII	31·30	5·56	38·72	22·72	1·70	17·82	29·59	32·24	20·35
LXXXIV	25·73	4·45	45·79	22·12	1·91	16·96	31·87	30·53	20·64
LXXXV	27·48	6·42	43·00	22·54	·56	10·42	29·14	35·94	24·50
LXXXVI	29·78	6·90	39·91	21·92	1·49	20·44	26·55	30·92	22·09
LXXXVII	32·68	5·77	38·82	21·70	1·03	17·78	27·73	31·91	22·58
LXXXVIII	33·53	5·20	35·58	23·98	1·71	22·13	24·64	29·12	24·11
LXXXIX	28·71	5·22	42·13	23·31	·63	14·22	27·99	37·18	20·61
XC	32·11	7·67	35·20	23·27	1·75	22·60	27·11	29·44	20·85
XCI	35·05	6·11	29·48	26·04	3·32	23·15	27·44	26·90	22·51
XCII	25·22	4·68	39·27	29·61	1·22	18·30	27·74	32·28	21·68
XCIII	32·03	4·04	36·26	25·58	2·09	21·16	31·21	28·87	18·76
XCIV	28·18	10·61	27·57	31·52	2·12	29·70	35·45	21·52	13·33
XCV	26·70	4·05	37·59	29·78	1·88	13·84	29·38	32·84	23·94
XCVI	34·93	5·21	36·04	22·72	1·10	22·62	29·03	24·53	23·82
XCVII	31·81	4·85	34·34	26·40	2·60	14·43	29·68	32·29	23·60
XCVIII	25·55	4·21	45·24	23·90	1·10	13·38	31·22	29·85	25·55
XCIX	31·17	3·93	31·81	30·97	2·12	19·70	30·46	26·40	23·44
C	28·83	5·38	30·05	32·08	3·66	16·95	31·78	30·56	20·71
CI	26·12	4·91	37·69	29·88	1·40	12·89	34·09	33·39	19·63
CII	27·04	5·66	35·33	30·50	1·47	14·05	38·99	27·04	19·92
CIII	27·88	4·25	38·54	27·02	2·31	16·71	29·83	31·63	21·83
CIV	25·11	5·48	40·89	26·93	1·59	12·19	32·24	33·76	21·81
CV	30·15	3·34	34·95	30·01	1·55	16·58	33·49	27·41	22·52
CVI	31·71	3·13	41·86	22·98	·32	7·34	35·60	35·38	21·68
CVII	21·94	6·54	43·25	25·74	2·53	20·89	35·44	20·89	22·78
CVIII	28·30	5·03	38·70	25·84	2·13	20·58	27·41	30·03	21·98
CIX	32·59	4·95	38·23	23·04	1·19	18·26	30·49	32·82	18·43
CX	33·48	5·67	36·14	23·12	1·59	25·16	24·09	27·46	23·29

TABLE XV.

County and Parish Data.

ABERDEEN.

Parish	BOYS										District	GIRLS									
	HAIR					EYES				Totals		HAIR					EYES				Totals
	Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark			Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark	
Aberdeen (Burgh) ...	2868	727	5061	2943	86	1494	3613	3908	2670	11685	*77*	2903	594	4342	2725	73	1482	3168	3582	2405	10637
Aberdour	32	12	60	48	6	34	37	53	34	158	*83*	24	12	48	31	4	20	31	34	34	119
Aboyne & Glen Tanar	32	12	49	53	0	24	43	51	28	146	*79*	39	12	52	44	0	16	60	39	32	147
Alford	34	19	67	15	3	46	41	29	22	138	*80*	42	14	52	25	4	46	37	31	23	137
Ardallie	21	5	48	13	0	21	35	21	10	87	*82*	14	1	44	20	0	17	39	19	4	79
Auchterless ...	28	6	73	27	2	27	46	39	24	136	*82*	24	8	50	26	1	15	38	42	14	109
Belhelvie	49	7	62	34	5	29	28	64	36	157	*78*	54	8	74	21	2	26	36	56	41	159
Birse	13	2	27	28	0	7	29	25	9	70	*79*	28	2	18	20	0	13	27	21	7	68
Bourtie	8	4	4	6	0	3	8	0	11	22	*80*	8	3	4	4	0	4	10	0	5	19
Cairney	46	10	43	28	0	23	30	38	36	127	*87*	44	5	46	28	2	21	25	38	41	125
Chapel of Garioch ...	36	5	27	18	0	17	31	25	13	86	*80*	39	5	46	29	0	27	31	34	27	119
Clatt	11	3	8	7	0	3	20	4	2	29	*80*	15	1	9	9	0	3	25	3	3	34
Cluny	21	4	52	7	2	28	15	29	14	86	*80*	25	5	35	19	0	14	30	24	16	84
Coull	4	1	12	11	0	3	6	8	11	28	*79*	6	0	10	6	2	8	6	6	4	24
Crathie and Braemar	27	12	33	29	1	16	37	35	14	102	*79*	21	5	48	23	1	22	21	31	24	98
Cruden	58	10	85	46	8	37	58	53	59	207	*78*	64	5	71	57	8	25	66	57	57	205
Culsalmond	11	0	10	4	1	10	4	10	2	26	*80*	6	3	9	11	0	8	5	11	5	29
Drumblade	16	6	26	21	1	24	11	11	24	70	*87*	25	3	26	13	0	31	13	13	10	67
Drumoak	13	4	40	26	2	16	25	25	19	85	*79*	18	4	21	17	1	7	23	16	15	61
Dyce	29	5	53	49	1	36	36	33	22	137	*80*	27	4	35	31	0	12	45	21	19	97
Echt	20	6	41	31	0	29	22	26	21	98	*79*	42	4	40	28	0	25	33	37	19	114
Ellon	88	22	191	64	6	45	115	138	73	371	*82*	91	10	182	54	2	35	100	136	68	339
Fintray	13	2	24	28	0	2	30	25	10	67	*80*	11	1	27	25	0	2	27	23	12	64
Forgue	13	5	63	47	1	20	30	51	28	129	*87*	34	8	35	30	0	18	27	39	23	107
Foveran	36	9	106	35	3	9	62	86	32	189	*78*	59	8	88	39	0	16	71	75	32	194
Fraserburgh ...	303	56	437	230	12	176	314	391	157	1038	*83*	352	55	396	249	14	175	327	352	212	1066
Fyvie	50	12	97	41	0	13	78	79	30	200	*82*	81	12	59	50	4	12	78	68	48	206
Gartly	9	2	33	20	0	16	23	17	8	64	*87*	8	3	26	18	1	17	25	11	3	56
Glass	11	1	42	18	3	21	15	25	14	75	*87*	15	3	35	15	3	17	16	20	18	71
Glenbucket ...	16	7	9	1	0	16	11	3	3	33	*80*	13	4	6	7	0	11	10	0	9	30
Glenmuick & Tullich	55	8	65	31	1	25	45	60	30	160	*79*	54	7	65	38	2	16	44	69	37	166
Huntly	133	21	182	117	4	67	134	137	119	457	*87*	144	29	193	113	5	76	122	152	134	484
Insch	32	9	59	35	0	23	37	58	17	135	*80*	45	5	24	36	4	28	31	34	21	114
Inverurie	132	28	166	114	3	89	101	168	85	443	*80*	133	22	144	68	3	65	96	139	70	370
Keig	21	3	11	20	6	16	14	13	18	61	*80*	22	2	9	6	1	17	12	5	6	40
Keithhall & Kinkell	7	3	30	13	2	10	16	19	10	55	*80*	16	3	33	13	3	15	17	25	11	68
Kennethmont ...	38	8	13	19	1	19	31	10	19	79	*80*	37	4	23	19	0	12	39	19	13	83
Kincardine O'Neil ...	41	9	133	37	7	35	80	88	24	227	*79*	53	8	88	38	7	28	80	63	23	194

King Edward	27	4	15	6	0	0	27	11	14	52	*86*	28	9	13	10	0	0	31	12	17	60
Kininmonth ...	20	3	22	25	0	29	1	32	8	70	*84*	20	0	24	11	1	18	7	18	13	56
Kinellar	17	4	11	10	1	1	23	13	6	43	*80*	8	3	12	7	0	2	9	12	7	30
Kintore	66	9	149	64	4	49	97	91	55	292	*80*	86	14	87	62	3	45	84	84	39	252
Leochel Cushnie ...	38	15	64	45	5	38	65	28	36	167	*80*	47	15	47	46	1	41	57	30	28	156
Leslie	10	5	12	18	0	0	21	13	11	45	*80*	8	2	16	7	0	0	16	3	14	33
Logie Buchan ...	11	4	20	13	2	6	16	15	13	50	*78*	4	0	21	11	1	3	9	19	6	37
Logie Coldstone ...	10	3	24	20	0	0	33	8	16	57	*79*	17	1	26	20	1	1	43	2	19	65
Longside	48	10	98	46	1	49	41	71	42	203	*84*	48	8	99	44	1	46	41	84	29	200
Lonmay	43	6	74	43	9	46	38	48	43	175	*83*	38	10	73	35	2	37	30	54	37	158
Lumphanan ...	18	8	36	17	0	3	40	27	9	79	*79*	16	8	17	14	0	1	29	20	5	55
Meldrum	39	13	96	54	0	32	61	69	40	202	*82*	54	12	76	54	1	39	46	56	56	197
Methlick	55	10	54	40	2	29	67	31	34	161	*82*	59	2	65	43	1	31	66	36	37	170
Midmar	17	7	38	21	0	19	27	23	14	83	*79*	9	4	26	26	0	19	19	13	14	65
Millbrex	15	5	19	23	3	2	21	26	16	65	*82*	18	3	27	21	0	4	9	33	23	69
Monquhitter ...	45	11	71	58	2	33	56	50	48	187	*82*	70	12	58	46	1	24	57	65	41	187
Monymusk	18	13	54	35	1	15	33	48	25	121	*80*	41	5	40	32	1	14	34	48	23	119
New Byth	39	7	40	28	5	44	24	32	19	119	*86*	43	7	60	25	3	68	18	26	26	138
New Deer	74	22	176	79	6	66	100	122	69	357	*84*	85	10	169	81	7	61	107	112	72	352
Newhills	122	31	223	99	0	43	150	183	99	475	*78*	124	36	221	106	2	37	154	204	94	489
New Machar ...	42	12	66	54	4	3	57	69	49	178	*78*	39	6	70	47	0	3	65	70	24	162
New Pitsligo ...	65	21	143	41	4	35	113	78	48	274	*84*	44	13	123	36	3	33	84	49	53	219
Old Deer	68	34	162	134	3	40	137	148	76	401	*84*	81	21	148	95	14	31	121	125	82	359
Old Machar	22	3	46	36	1	17	35	42	14	108	*78*	29	6	32	23	2	15	28	33	16	92
Oyne	17	5	22	12	0	14	16	18	8	56	*80*	20	1	22	13	0	19	18	13	6	56
Peterculter	125	24	113	75	3	87	67	135	51	340	*78*	113	24	123	73	6	88	71	117	63	339
Peterhead (Burgh) ...	303	89	666	346	15	169	388	504	358	1419	*81*	316	73	557	369	19	167	367	468	332	1334
,, (Land'd)...	54	9	118	87	11	39	66	110	64	279	*81*	58	10	111	92	6	42	57	89	89	277
Pitsligo	68	19	129	66	2	78	77	70	59	284	*83*	77	16	101	56	3	63	74	72	44	253
Premnay	15	0	24	21	0	0	11	38	11	60	*80*	16	4	12	17	0	3	14	19	13	49
Rathen	65	11	91	58	7	32	82	77	41	232	*83*	78	8	86	42	8	29	76	74	43	222
Rayne	23	3	67	11	0	12	28	48	16	104	*80*	23	3	56	13	1	22	21	41	12	96
Rhynie	28	4	22	14	0	26	11	19	12	68	*87*	26	1	17	8	2	16	9	21	8	54
St Fergus	49	4	33	18	1	10	52	21	22	105	*81*	65	1	38	13	1	25	47	26	20	118
Savoch	15	3	20	13	0	0	22	23	6	51	*82*	32	0	27	24	0	8	18	38	19	83
Skene	39	8	37	31	5	26	36	28	30	120	*79*	34	8	34	36	3	15	45	33	22	115
Slains	15	5	27	10	2	1	18	25	15	59	*78*	34	8	14	34	1	18	22	28	23	91
Strathdon	29	12	42	27	3	22	18	49	24	113	*80*	22	5	31	23	5	17	19	29	21	86
Strichen	50	19	97	39	0	57	72	31	45	205	*84*	68	10	79	38	1	48	83	31	34	196
Tarland	9	5	27	27	1	16	15	23	15	69	*79*	20	7	33	31	0	21	18	20	32	91
Tarves	40	8	47	37	1	45	17	44	27	133	*82*	39	12	36	40	7	36	34	46	18	134
Tough	41	5	14	5	9	6	17	29	22	74	*80*	22	2	6	2	8	5	10	12	13	40
Towie	20	5	33	14	0	20	20	21	11	72	*80*	22	2	22	11	0	14	24	10	9	57
Turriff	90	24	222	107	2	26	157	174	88	445	*86*	108	29	228	104	7	31	155	180	110	476
Tyrie	7	5	10	9	0	5	7	11	8	31	*84*	18	1	6	8	0	3	8	13	9	33
Udny	7	2	27	7	0	1	20	15	7	43	*82*	18	2	19	6	0	0	20	15	10	45
Ythan Wells ...	13	6	46	25	1	14	37	26	14	91	*82*	9	6	41	12	1	12	28	15	14	69
Totals ...	6426	1600	11189	6382	283	3844	7848	8682	5506	25880	—	6890	1322	9762	5972	271	3677	7293	7963	5284	24217

TABLE XV.

County and Parish Data.

ABERDEEN.

Parish	BOYS										District	GIRLS									
	Hair					Eyes				Totals		Hair					Eyes				Totals
	Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark			Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark	
Aberdeen (Burgh) ...	2868	727	5061	2943	86	1494	3613	3908	2670	11685	77	2903	594	4342	2725	73	1482	3168	3582	2405	10637
Aberdour	32	12	60	48	6	34	37	53	34	158	83	24	12	48	31	4	20	31	34	34	119
Aboyne & Glen Tanar	32	12	49	53	0	24	43	51	28	146	79	39	12	52	44	0	16	60	39	32	147
Alford	34	19	67	15	3	46	41	29	22	138	80	42	14	52	25	4	46	37	31	23	137
Ardallie	21	5	48	13	0	21	35	21	10	87	82	14	1	44	20	0	17	39	19	4	79
Auchterless ...	28	6	73	27	2	27	46	39	24	136	82	24	8	50	26	1	15	38	42	14	109
Belhelvie	49	7	62	34	5	29	28	64	36	157	78	54	8	74	21	2	26	36	56	41	159
Birse	13	2	27	28	0	7	29	25	9	70	79	28	2	18	20	0	13	27	21	7	68
Bourtie	8	4	4	6	0	3	8	0	11	22	80	8	3	4	4	0	4	10	0	5	19
Cairney	46	10	43	28	0	23	30	38	36	127	87	44	5	46	28	2	21	25	38	41	125
Chapel of Garioch ...	36	5	27	18	0	17	31	25	13	86	80	39	5	46	29	0	27	31	34	27	119
Clatt	11	3	8	7	0	3	20	4	2	29	80	15	1	9	9	0	3	25	3	3	34
Cluny	21	4	52	7	2	28	15	29	14	86	80	25	5	35	19	0	14	30	24	16	84
Coull	4	1	12	11	0	3	6	8	11	28	79	6	0	10	6	2	8	6	6	4	24
Crathie and Braemar	27	12	33	29	1	16	37	35	14	102	79	21	5	48	23	1	22	21	31	24	98
Cruden	58	10	85	46	8	37	58	53	59	207	78	64	5	71	57	8	25	66	57	57	205
Culsalmond	11	0	10	4	1	10	4	10	2	26	80	6	3	9	11	0	8	5	11	5	29
Drumblade	16	6	26	21	1	24	11	11	24	70	87	25	3	26	13	0	31	13	13	10	67
Drumoak	13	4	40	26	2	16	25	25	19	85	79	18	4	21	17	1	7	23	16	15	61
Dyce	29	5	53	49	1	36	36	33	22	137	80	27	4	35	31	0	12	45	21	19	97
Echt	20	6	41	31	0	29	22	26	21	98	79	42	4	40	28	0	25	33	37	19	114
Ellon	88	22	191	64	6	45	115	138	73	371	82	91	10	182	54	2	35	100	136	68	339
Fintray	13	2	24	28	0	2	30	25	10	67	80	11	1	27	25	0	2	27	23	12	64
Forgue	13	5	63	47	1	20	30	51	28	129	87	34	8	35	30	0	18	27	39	23	107
Foveran	36	9	106	35	3	9	62	86	32	189	78	59	8	88	39	0	16	71	75	32	194
Fraserburgh ...	303	56	437	230	12	176	314	391	157	1038	83	352	55	396	249	14	175	327	352	212	1066
Fyvie	50	12	97	41	0	13	78	79	30	200	82	81	12	59	50	4	12	78	68	48	206
Gartly	9	2	33	20	0	16	23	17	8	64	87	8	3	26	18	1	17	25	11	3	56
Glass	11	1	42	18	3	21	15	25	14	75	87	15	3	35	15	3	17	16	20	18	71
Glenbucket ...	16	7	9	1	0	16	11	3	3	33	80	13	4	6	7	0	11	10	0	9	30
Glenmuick & Tullich	55	8	65	31	1	25	45	60	30	160	79	54	7	65	38	2	16	44	69	37	166
Huntly	133	21	182	117	4	67	134	137	119	457	87	144	29	193	113	5	76	122	152	134	484
Insch	32	9	59	35	0	23	37	58	17	135	80	45	5	24	36	4	28	31	34	21	114
Inverurie	132	28	166	114	3	89	101	168	85	443	80	133	22	144	68	3	65	96	139	70	370
Keig	21	3	11	20	6	16	14	13	18	61	80	22	2	9	6	1	17	12	5	6	40
Keithhall & Kinkell	7	3	30	13	2	10	16	19	10	55	80	16	3	33	13	3	15	17	25	11	68
Kennethmont ...	38	8	13	19	1	19	31	10	19	79	80	37	4	23	19	0	12	39	19	13	83
Kincardine O'Neil ...	41	9	133	37	7	35	80	88	24	227	79	53	8	88	38	7	28	80	63	23	194
King Edward ...	27	4	15	6	0	0	27	11	14	52	86	28	9	13	10	0	0	31	12	17	60
Kininmonth ...	20	3	22	25	0	29	1	32	8	70	84	20	0	24	11	1	18	7	18	13	56
Kinellar	17	4	11	10	1	1	23	13	6	43	80	8	3	12	7	0	2	9	12	7	30
Kintore	66	9	149	64	4	49	97	91	55	292	80	86	14	87	62	3	45	84	84	39	252
Leochel Cushnie ...	38	15	64	45	5	38	65	28	36	167	80	47	15	47	46	1	41	57	30	28	156
Leslie	10	5	12	18	0	0	21	13	11	45	80	8	2	16	7	0	0	16	3	14	33
Logie Buchan ...	11	4	20	13	2	6	16	15	13	50	78	4	0	21	11	1	3	9	19	6	37
Logie Coldstone ...	10	3	24	20	0	0	33	8	16	57	79	17	1	26	20	1	1	43	2	19	65
Lougside	48	10	98	46	1	49	41	71	42	203	84	48	8	99	44	1	46	41	84	29	200
Lonmay	43	6	74	43	9	46	38	48	43	175	83	38	10	73	35	2	37	30	54	37	158
Lumphanan ...	18	8	36	17	0	3	40	27	9	79	79	16	8	17	14	0	1	29	20	5	55
Meldrum	39	13	96	54	0	32	61	69	40	202	82	54	12	76	54	1	39	46	56	56	197
Methlick	55	10	54	40	2	29	67	31	34	161	82	59	2	65	43	1	31	66	36	37	170
Midmar	17	7	38	21	0	19	27	23	14	83	79	9	4	26	26	0	19	19	13	14	65
Millbrex	15	5	19	23	3	2	21	26	16	65	82	18	3	27	21	0	4	9	33	23	69
Monquhitter ...	45	11	71	58	2	33	56	50	48	187	82	70	12	58	46	1	24	57	65	41	187
Monymusk	18	13	54	35	1	15	33	48	25	121	80	41	5	40	32	1	14	34	48	23	119
New Byth	39	7	40	28	5	44	24	32	19	119	86	43	7	60	25	3	68	18	26	26	138
New Deer	74	22	176	79	6	66	100	122	69	357	84	85	10	169	81	7	61	107	112	72	352
Newhills	122	31	223	99	0	43	150	183	99	475	78	124	36	221	106	2	37	154	204	94	489
New Machar ...	42	12	66	54	4	3	57	69	49	178	78	39	6	70	47	0	3	65	70	24	162
New Pitsligo ...	65	21	143	41	4	35	113	78	48	274	84	44	13	123	36	3	33	84	49	53	219
Old Deer	68	34	162	134	3	40	137	148	76	401	84	81	21	148	95	14	31	121	125	82	359
Old Machar	22	3	46	36	1	17	35	42	14	108	78	29	6	32	23	2	15	28	33	16	92
Oyne	17	5	22	12	0	14	16	18	8	56	80	20	1	22	13	0	19	18	13	6	56
Peterculter	125	24	113	75	3	87	67	135	51	340	78	113	24	123	73	6	88	71	117	63	339
Peterhead (Burgh) ...	303	89	666	346	15	169	388	504	358	1419	81	316	73	557	369	19	167	367	468	332	1334
,, (Land'd)...	54	9	118	87	11	39	66	110	64	279	81	58	10	111	92	6	42	57	89	89	277
Pitsligo	68	19	129	66	2	78	77	70	59	284	83	77	16	101	56	3	63	74	72	44	253
Premnay	15	0	24	21	0	0	11	38	11	60	80	16	4	12	17	0	3	14	19	13	49
Rathen	65	11	91	58	7	32	82	77	41	232	83	78	8	86	42	8	29	76	74	43	222
Rayne	23	3	67	11	0	12	28	48	16	104	80	23	3	56	13	1	22	21	41	12	96
Rhynie	28	4	22	14	0	26	11	19	12	68	87	26	1	17	8	2	16	9	21	8	54
St Fergus	49	4	33	18	1	10	52	21	22	105	81	65	1	38	13	1	25	47	26	20	118
Savoch	15	3	20	13	0	0	22	23	6	51	82	32	0	27	24	0	8	18	38	19	83
Skene	39	8	37	31	5	26	36	28	30	120	79	34	8	34	36	3	15	45	33	22	115
Slains	15	5	27	10	2	1	18	25	15	59	78	34	8	14	34	1	18	22	28	23	91
Strathdon	29	12	42	27	3	22	18	49	24	113	80	22	5	31	23	5	17	19	29	21	86
Strichen	50	19	97	39	0	57	72	31	45	205	84	68	10	79	38	1	48	83	31	34	196
Tarland	9	5	27	27	1	16	15	23	15	69	79	20	7	33	31	0	21	18	20	32	91
Tarves	40	8	47	37	1	45	17	44	27	133	82	39	12	36	40	7	36	34	46	18	134
Tough	41	5	14	5	9	6	17	29	22	74	80	22	2	6	2	8	5	10	12	13	40
Towie	20	5	33	14	0	20	20	21	11	72	80	22	2	22	11	0	14	24	10	9	57
Turriff	90	24	222	107	2	26	157	174	88	445	86	108	29	228	104	7	31	155	180	110	476
Tyrie	7	5	10	9	0	5	7	11	8	31	84	18	1	6	8	0	3	8	13	9	33
Udny	7	2	27	7	0	1	20	15	7	43	82	18	2	19	6	0	0	20	15	10	45
Ythan Wells ...	13	6	46	25	1	14	37	26	14	91	82	9	6	41	12	1	12	28	15	14	69
Totals ...	6426	1600	11189	6382	283	3844	7848	8682	5506	25880	–	6890	1322	9762	5972	271	3677	7293	7963	5284	24217

TABLE XV.—(*continued*).

County and Parish Data.

ARGYLL.

Parish	BOYS Hair Fair	Red	Medium	Dark	Jet Black	Eyes Blue	Light	Medium	Dark	Totals	District	GIRLS Hair Fair	Red	Medium	Dark	Jet Black	Eyes Blue	Light	Medium	Dark	Totals
Acharacle	7	5	10	22	0	5	18	15	6	44	*100*	6	3	10	14	0	6	12	11	4	33
Ardchattan and Muckairn ...	16	2	18	10	3	4	10	17	18	49	*101*	21	4	16	15	0	7	17	19	13	56
Ardgour	14	3	17	19	1	7	21	11	15	54	*100*	18	3	6	23	1	11	14	13	13	51
Ardnamurchan	0	1	2	13	0	3	1	8	4	16	*100*	0	1	5	12	0	4	1	12	1	18
Campbeltown (Burgh) ...	223	53	393	269	10	178	262	311	197	948	*103*	229	43	352	265	26	135	298	284	198	915
„ (Landward) ...	43	4	49	34	5	24	21	55	35	135	*103*	51	6	55	30	1	40	21	51	31	143
Coll	15	4	21	10	0	5	18	26	1	50	*100*	9	3	18	10	0	5	15	16	4	40
Colonsay and Oronsay ...	0	0	16	8	0	6	15	2	1	24	*102*	2	0	6	8	0	3	10	1	2	16
Craignish	8	1	22	8	1	1	26	12	1	40	*101*	9	0	15	7	1	1	20	11	0	32
Cumlodden	21	3	16	12	1	6	26	3	18	53	*101*	12	2	5	13	0	3	16	9	4	32
Dunoon and Kilmun ...	143	41	306	198	11	92	188	269	150	699	*104*	147	28	283	163	13	71	190	218	155	634
Gigha and Cara	19	1	13	8	0	4	30	5	2	41	*102*	18	2	8	8	0	6	20	7	3	36
Glassary	33	3	21	22	0	30	15	22	12	79	*101*	26	4	18	25	2	19	21	23	12	75
Glenaray & Inveraray (Burgh)	8	0	6	1	2	9	0	3	5	17	*101*	8	0	1	2	2	8	0	3	2	13
Glenorchy and Inishail ...	10	3	21	13	0	2	22	14	9	47	*101*	11	4	16	22	0	11	16	16	10	53
Inverchaolain	0	1	4	4	0	2	2	2	3	9	*104*	5	0	3	4	0	2	5	2	3	12
Jura	4	1	16	17	0	2	13	17	6	38	*102*	9	1	20	13	0	8	15	13	7	43
Kilbrandon and Kilchattan	21	1	29	25	0	7	34	27	8	76	*101*	16	1	19	21	0	6	23	17	11	57
Kilcalmonell	15	2	12	24	1	7	26	1	20	54	*102*	10	3	13	16	0	6	18	6	12	42
Kilchoman	59	13	88	65	2	17	97	78	35	227	*102*	62	13	79	44	5	21	94	45	43	203
Kilchrenan and Dalavich ...	11	7	22	7	0	11	11	21	4	47	*101*	18	4	24	10	0	19	17	11	9	56
Kildalton	33	6	68	57	3	28	61	32	46	167	*102*	41	6	53	45	3	33	38	43	34	148
Kilfinan	38	4	69	42	1	20	84	33	17	154	*102*	42	7	53	42	1	27	69	33	16	145
Kilfinichen and Kilvickeon	41	7	38	53	4	27	58	31	27	143	*100*	28	3	25	49	2	19	39	25	24	107
Killarrow and Kilmeny ...	63	8	62	119	5	27	85	89	56	257	*102*	45	11	63	79	3	18	62	68	53	201
Killean and Kilchenzie ...	20	3	27	10	3	27	5	20	11	63	*103*	33	6	32	9	2	37	11	19	15	82
Kilmartin	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Kilmodan	3	0	9	6	2	4	3	4	9	20	*104*	9	0	5	6	0	7	5	2	6	20
Kilmore and Kilbride ...	1	0	4	1	0	1	3	2	0	6	*101*	2	0	6	4	0	1	4	3	4	12
Kilninian and Kilmore ...	31	5	31	42	4	10	36	38	29	113	*100*	36	9	46	47	1	14	43	59	23	139
Kilninver and Kilmelford ...	4	1	9	1	1	6	4	5	1	16	*101*	2	0	1	3	2	2	0	5	1	8
Lismore and Appin	54	10	69	82	7	53	67	42	60	222	*101*	53	14	65	58	9	58	57	46	38	199
Lochgilphead	20	9	28	56	0	1	39	46	27	113	*101*	53	4	36	38	0	6	36	35	34	111
Lochgoilhead and Kilmorich	9	3	15	6	0	6	13	6	8	33	*101*	9	1	10	9	0	1	13	6	9	29
Morvern	18	1	17	8	0	15	10	16	3	44	*100*	19	5	12	13	1	10	12	18	10	50

North Knapdale	3	0	8	5	0	0	6	8	2	16	*102*	4	1	8	7	0	0	6	10	4	20
Oban (Burgh)	61	24	173	129	0	3	160	158	66	387	*101*	66	16	170	98	0	1	134	150	65	350
Saddell and Skipness ...	13	6	21	34	1	9	36	19	11	75	*102*	14	6	24	19	0	8	28	18	9	63
Salen	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Small Isles	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Southend	29	5	21	12	0	0	22	39	6	67	*103*	19	2	11	10	1	0	16	16	11	43
S. Knapdale	14	1	11	12	0	10	13	10	5	38	*102*	11	4	10	10	2	4	12	14	7	37
Stralachlan and Strachur ...	5	1	5	1	2	2	5	6	1	14	*101*	8	1	10	4	0	4	9	7	3	23
Strontian	9	2	22	11	2	3	24	3	16	46	*100*	11	4	13	6	2	5	21	7	3	36
Tarbert	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Torosay	20	2	13	5	1	8	17	12	4	41	*100*	13	0	7	10	2	11	8	8	5	32
Tyree	43	10	44	32	4	27	51	35	20	133	*100*	37	4	44	33	4	30	38	38	16	122
Totals	1202	257	1866	1513	77	709	1658	1573	975	4915	—	1222	229	1676	1324	86	688	1504	1418	927	4537

AYR.

Alloway	24	0	45	28	1	2	41	30	25	98	*31*	30	7	42	19	1	4	40	29	26	99
Ardrossan	112	36	241	176	4	45	223	188	113	569	*29*	200	33	259	133	4	14	156	340	119	629
Auchinleck	92	31	207	118	5	34	160	168	91	453	*26*	149	39	199	98	5	50	158	180	102	490
Ayr (Burgh)	340	88	507	368	18	169	447	392	313	1321	*25*	332	59	511	333	6	177	425	364	275	1241
Ballantrae	3	2	6	11	0	4	3	6	9	22	*32*	4	1	8	8	0	4	7	6	4	21
Barr	1	2	2	2	0	0	3	2	2	7	*31*	1	1	1	1	0	0	0	1	3	4
Beith	170	35	249	132	7	98	175	201	119	593	*30*	183	39	230	150	7	105	195	178	131	609
Colmonell	34	7	70	51	2	39	34	61	30	164	*32*	47	13	62	47	1	41	29	64	36	170
Coylton	67	13	79	67	4	71	59	43	57	230	*31*	86	16	67	36	5	78	57	26	49	210
Crosshill	24	4	36	31	2	22	33	26	16	97	*31*	32	5	33	37	2	23	36	29	21	109
Dailly	22	1	17	31	2	27	22	6	18	73	*31*	15	4	15	26	0	26	9	4	21	60
Dalmellington	40	7	104	36	0	2	99	56	30	187	*31*	55	10	95	39	0	7	97	63	32	199
Dalry	159	30	223	152	9	62	212	201	98	573	*30*	134	19	196	116	14	65	157	163	94	479
Dalrymple	23	9	85	30	2	8	57	45	39	149	*31*	20	5	77	26	2	8	47	43	32	130
Dreghorn	99	18	45	51	0	24	102	61	26	213	*28*	96	4	67	34	0	16	111	55	19	201
Dundonald	123	24	274	157	11	93	148	207	141	589	*28*	118	23	248	125	11	94	152	158	121	525
Dunlop	23	3	54	15	1	6	57	20	13	96	*30*	20	8	41	19	1	2	48	31	8	89
Fenwick	19	3	24	5	0	0	41	10	0	51	*30*	14	0	23	3	0	0	25	15	0	40
Galston	143	32	266	108	20	115	153	175	126	569	*28*	149	22	182	122	4	93	161	129	96	479
Girvan (Town)	102	13	78	100	6	46	94	95	64	299	*31*	103	11	97	69	3	51	81	90	61	283
„ (Landward)	23	9	105	62	1	20	38	89	53	200	*31*	21	13	86	65	4	15	36	87	51	189
Irvine (Burgh)	170	39	242	174	7	95	205	163	169	632	*28*	181	20	257	174	8	109	186	180	165	640
„ (Landward)	33	5	38	18	1	29	31	3	32	95	*28*	19	11	34	16	0	19	36	3	22	80
Kilbirnie	213	26	227	120	2	119	210	140	119	588	*30*	183	34	212	162	3	109	215	147	123	594
Kilmarnock (Burgh) ...	522	127	1002	522	21	309	754	672	459	2194	*27*	470	89	977	507	15	274	700	637	447	2058
„ (Landward) ...	57	14	64	43	2	9	70	41	60	180	*28*	42	11	57	48	1	11	56	47	45	159
Kilmaurs	170	18	215	78	1	5	218	170	89	482	*28*	136	31	177	85	1	14	174	139	103	430
Kilwinning	137	32	302	134	2	79	225	184	119	607	*30*	154	32	261	91	3	62	193	185	101	541
Kirkmichael	21	2	9	6	0	9	12	12	5	38	*31*	39	2	10	9	3	22	13	16	12	63

TABLE XV.—(*continued*).

County and Parish Data.

ARGYLL.

Parish	BOYS										District	GIRLS									
	Hair					Eyes				Totals		Hair					Eyes				Totals
	Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark			Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark	
Acharacle	7	5	10	22	0	5	18	15	6	44	*100*	6	3	10	14	0	6	12	11	4	33
Ardchattan and Muckairn ...	16	2	18	10	3	4	10	17	18	49	*101*	21	4	16	15	0	7	17	19	13	56
Ardgour	14	3	17	19	1	7	21	11	15	54	*100*	18	3	6	23	1	11	14	13	13	51
Ardnamurchan	0	1	2	13	0	3	1	8	4	16	*100*	0	1	5	12	0	4	1	12	1	18
Campbeltown (Burgh) ...	223	53	393	269	10	178	262	311	197	948	*103*	229	43	352	265	26	135	298	284	198	915
„ (Landward) ...	43	4	49	34	5	24	21	55	35	135	*103*	51	6	55	30	1	40	21	51	31	143
Coll	15	4	21	10	0	5	18	26	1	50	*100*	9	3	18	10	0	5	15	16	4	40
Colonsay and Oronsay ...	0	0	16	8	0	6	15	2	1	24	*102*	2	0	6	8	0	3	10	1	2	16
Craignish	8	1	22	8	1	1	26	12	1	40	*101*	9	0	15	7	1	1	20	11	0	32
Cumlodden	21	3	16	12	1	6	26	3	18	53	*101*	12	2	5	13	0	3	16	9	4	32
Dunoon and Kilmun ...	143	41	306	198	11	92	188	269	150	699	*104*	147	28	283	163	13	71	190	218	155	634
Gigha and Cara	19	1	13	8	6	4	30	5	2	41	*102*	18	2	8	8	0	6	20	7	3	36
Glassary	33	3	21	22	0	30	15	22	12	79	*101*	26	4	18	25	2	19	21	23	12	75
Glenaray & Inveraray (Burgh)	8	0	6	1	2	9	0	3	5	17	*101*	8	0	1	2	2	8	0	3	2	13
Glenorchy and Inishail ...	10	3	21	13	0	2	22	14	9	47	*101*	11	4	16	22	0	11	16	16	10	53
Inverchaolain	0	1	4	4	0	2	2	2	3	9	*104*	5	0	3	4	0	2	5	2	3	12
Jura	4	1	16	17	0	2	13	17	6	38	*102*	9	1	20	13	0	8	15	13	7	43
Kilbrandon and Kilchattan	21	1	29	25	0	7	34	27	8	76	*101*	16	1	19	21	0	6	23	17	11	57
Kilcalmonell	15	2	12	24	1	7	26	1	20	54	*102*	10	3	13	16	0	6	18	6	12	42
Kilchoman	59	13	88	65	2	17	97	78	35	227	*102*	62	13	79	44	5	21	94	45	43	203
Kilchrenan and Dalavich ...	11	7	22	7	0	11	11	21	4	47	*101*	18	4	24	10	0	19	17	11	9	56
Kildalton	33	6	68	57	3	28	61	32	46	167	*102*	41	6	53	45	3	33	38	43	34	148
Kilfinan	38	4	69	42	1	20	84	33	17	154	*102*	42	7	53	42	1	27	69	33	16	145
Kilfinichen and Kilvickeon	41	7	38	53	4	27	58	31	27	143	*100*	28	3	25	49	2	19	39	25	24	107
Killarrow and Kilmeny ...	63	8	62	119	5	27	85	89	56	257	*102*	45	11	63	79	3	18	62	68	53	201
Killean and Kilchenzie ...	20	3	27	10	3	27	5	20	11	63	*103*	33	6	32	9	2	37	11	19	15	82
Kilmartin	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Kilmodan	3	0	9	6	2	4	3	4	9	20	*104*	9	0	5	6	0	7	5	2	6	20
Kilmore and Kilbride ...	1	0	4	1	0	1	3	2	0	6	*101*	2	0	6	4	0	1	4	3	4	12
Kilninian and Kilmore ...	31	5	31	42	4	10	36	38	29	113	*100*	36	9	46	47	1	14	43	59	23	139
Kilninver and Kilmelford ...	4	1	9	1	1	6	4	5	1	16	*101*	2	0	1	3	2	2	0	5	1	8
Lismore and Appin	54	10	69	82	7	53	67	42	60	222	*101*	53	14	65	58	9	58	57	46	38	199
Lochgilphead	20	9	28	56	0	1	39	46	27	113	*101*	53	4	36	38	0	6	36	35	34	111
Lochgoilhead and Kilmorich	9	3	15	6	0	6	13	6	8	33	*101*	9	1	10	9	0	1	13	6	9	29
Morvern	18	1	17	8	0	15	10	16	3	44	*100*	19	5	12	13	1	10	12	18	10	50
North Knapdale	3	0	8	5	0	0	6	8	2	16	*102*	4	1	8	7	0	0	6	10	4	20
Oban (Burgh)	61	24	173	129	0	3	160	158	66	387	*101*	66	16	170	98	0	1	134	150	65	350
Saddell and Skipness ..	13	6	21	34	1	9	36	19	11	75	*102*	14	6	21	19	0	8	28	18	9	63
Salen	—	—	—	—	—	—	—	—	—	—	—									—	
Small Isles	—	—	—			—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Southend	29	5	21	12	0	0	22	39	6	67	*103*	19	2	11	10	1	0	16	16	11	43
S. Knapdale	14	1	11	12	0	10	13	10	5	38	*102*	11	4	10	10	2	4	12	14	7	37
Stralachlan and Strachur ...	5	1	5	1	2	2	5	6	1	14	*101*	8	1	10	4	0	4	9	7	3	23
Strontian	9	2	22	11	2	3	24	3	16	46	*100*	11	4	13	6	2	5	21	7	3	36
Tarbert	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Torosay	20	2	13	5	1	8	17	12	4	41	*100*	13	0	7	10	2	11	8	8	5	32
Tyree	43	10	44	32	4	27	51	35	20	133	*100*	37	4	44	33	4	30	38	38	16	122
Totals	1202	257	1866	1513	77	709	1658	1573	975	4915	—	1222	229	1676	1324	86	688	1504	1418	927	4537

AYR.

Parish	BOYS										District	GIRLS									
	Hair					Eyes				Totals		Hair					Eyes				Totals
	Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark			Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark	
Alloway	24	0	45	28	1	2	41	30	25	98	*31*	30	7	42	19	1	4	40	29	26	99
Ardrossan	112	36	241	176	4	45	223	188	113	569	*29*	200	33	259	133	4	14	156	340	119	629
Auchinleck	92	31	207	118	5	34	160	168	91	453	*26*	149	39	199	98	5	50	158	180	102	490
Ayr (Burgh)	340	88	507	368	18	169	447	392	313	1321	*25*	332	59	511	333	6	177	425	364	275	1241
Ballantrae	3	2	6	11	0	4	3	6	9	22	*32*	4	1	8	8	0	4	7	6	4	21
Barr	1	2	2	2	0	0	3	2	2	7	*31*	1	1	1	1	0	0	0	1	3	4
Beith	170	35	249	132	7	98	175	201	119	593	*30*	183	39	230	150	7	105	195	178	131	609
Colmonell .	34	7	70	51	2	39	34	61	30	164	*32*	47	13	62	47	1	41	29	64	36	170
Coylton	67	13	79	67	4	71	59	43	57	230	*31*	86	16	67	36	5	78	57	26	49	210
Crosshill	24	4	36	31	2	22	33	26	16	97	*31*	32	5	33	37	2	23	36	29	21	109
Dailly	22	1	17	31	2	27	22	6	18	73	*31*	15	4	15	26	0	26	9	4	21	60
Dalmellington	40	7	104	36	0	2	99	56	30	167	*31*	55	10	95	39	0	7	97	63	32	199
Dalry	159	30	223	152	9	62	212	201	98	573	*30*	134	19	196	116	14	65	157	163	94	479
Dalrymple	23	9	85	30	2	8	57	45	39	149	*31*	20	5	77	26	2	8	47	43	32	130
Dreghorn .	99	18	45	51	0	24	102	61	26	213	*28*	96	4	67	34	0	16	111	55	19	201
Dundonald	123	24	274	157	11	93	148	207	141	589	*28*	118	23	248	125	11	94	152	158	121	525
Dunlop	23	3	54	15	1	6	57	20	13	96	*30*	20	8	41	19	1	2	48	31	8	89
Fenwick	19	3	24	5	0	0	41	10	0	51	*30*	14	0	23	3	0	0	25	15	0	40
Galston	143	32	266	108	20	115	153	175	126	569	*28*	149	22	182	122	4	93	161	129	96	479
Girvan (Town)	102	13	78	100	6	46	94	95	64	299	*31*	103	11	97	69	3	51	81	90	61	283
„ (Landward)	23	9	105	62	1	20	38	89	53	200	*31*	21	13	86	65	4	15	36	87	51	189
Irvine (Burgh)	170	39	242	174	7	95	205	163	169	632	*28*	181	20	257	174	8	109	186	180	165	640
„ (Landward)	33	5	38	18	1	29	31	3	32	95	*28*	19	11	34	16	0	19	36	3	22	80
Kilbirnie	213	26	227	120	2	119	210	140	119	588	*30*	183	34	212	162	3	109	215	147	123	594
Kilmarnock (Burgh) .	522	127	1002	522	21	309	754	672	459	2194	*27*	470	89	977	507	15	274	700	637	447	2058
„ Landward) ...	57	14	64	43	2	9	70	41	60	180	*28*	42	11	57	48	1	11	56	47	45	159
Kilmaurs	170	18	215	78	1	5	218	170	89	482	*28*	136	31	177	85	1	14	174	139	103	430
Kilwinning	137	32	302	134	2	79	225	184	119	607	*30*	154	32	261	91	3	62	193	185	101	541
Kirkmichael	21	2	9	6	0	9	12	12	5	38	*31*	39	2	10	9	3	22	13	16	12	63

TABLE XV.—(*continued*).

County and Parish Data.

AYR—(*continued*).

Parish	BOYS											GIRLS									
	HAIR					EYES				Totals	District	HAIR					EYES				Totals
	Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark			Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark	
Kirkoswald	12	2	26	5	1	0	14	20	12	46	*31*	14	1	17	11	0	3	14	15	11	43
Largs	17	1	26	8	2	5	12	29	8	54	*23*	22	1	20	11	2	7	13	26	10	56
Loudoun	132	20	162	90	16	190	96	69	65	420	*28*	173	23	140	105	9	179	103	74	94	450
Mauchline	61	4	183	64	1	27	85	135	66	313	*26*	79	4	161	62	0	29	103	114	60	306
Maybole & Maybole W. Church	140	33	307	243	5	64	160	307	197	728	*31*	138	27	264	177	6	60	135	261	156	612
Monkton and Prestwick ...	74	12	106	24	2	19	44	106	49	218	*26*	70	12	92	34	4	25	53	96	38	212
Muirkirk	30	4	49	47	2	10	29	51	42	132	*26*	39	5	48	37	3	26	34	39	33	132
New Cumnock	104	31	118	85	2	89	106	85	60	340	*36*	128	16	108	90	0	78	110	91	63	342
Ochiltree	38	6	65	51	0	15	45	56	44	160	*26*	38	7	49	42	3	12	35	48	44	139
Old Cumnock	144	36	159	128	4	126	111	145	89	471	*26*	166	23	146	119	3	96	129	146	86	457
Riccarton	117	22	145	118	10	52	134	160	66	412	*28*	135	18	134	118	1	70	113	162	61	406
St Quivox (Landward) and Newton on Ayr (Landward)	13	1	24	12	8	12	14	22	10	58	*26*	9	0	24	5	1	8	9	18	4	39
Sorn	109	11	105	46	1	54	86	88	44	272	*26*	94	19	81	51	1	42	73	77	54	246
Stair	36	3	33	18	1	13	39	21	18	91	*26*	47	8	34	18	3	26	39	29	16	110
Stevenston	247	45	351	212	7	259	191	203	209	862	*29*	244	33	349	202	20	249	192	212	195	848
Stewarton	112	14	99	42	1	137	34	55	42	268	*30*	123	15	97	49	3	146	36	45	60	287
Straiton	16	3	12	11	0	14	7	7	14	42	*31*	16	0	6	12	0	14	9	1	10	34
Symington	16	3	3	13	4	16	5	7	11	39	*26*	19	1	9	8	2	21	6	6	6	39
Tarbolton	60	4	95	39	2	82	42	32	44	200	*26*	60	10	90	23	1	95	32	29	28	184
West Kilbride	32	8	93	34	3	23	58	60	29	170	*23*	40	10	90	65	5	29	73	62	46	210
Totals	4476	893	6977	4116	203	2748	5238	5125	3554	16665	—	4687	795	6483	3837	171	2708	4911	4960	3394	15973

BANFF.

Parish	Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark	Totals	District	Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark	Totals
Aberlour	71	21	86	77	9	84	64	43	73	264	*90*	84	27	75	66	4	70	63	62	61	256
Alvah	15	5	34	11	0	23	10	17	15	65	*86*	20	7	26	13	1	23	12	19	13	67
Banff (Burgh)	81	20	218	68	3	79	93	135	83	390	*85*	92	31	185	84	2	77	83	155	79	394
„ (Landward) and Ord ...	22	3	25	26	2	10	36	23	9	78	*85*	26	5	30	26	1	12	28	26	22	88
Bellie	—	—	—	—	—	—	—	—	—	—		—	—	—	—	—	—	—	—	—	—
Boharm	23	4	42	18	1	15	32	26	15	88	*90*	26	8	33	24	1	17	21	29	25	92
Botriphnie	28	2	24	7	0	7	23	24	7	61	*87*	26	4	19	9	0	2	29	13	14	58

Boyndie	49	4	112	35	0	22	60	86	32	200	*85*	57	9	110	25	1	16	84	67	35	202
Cabrach	23	5	18	14	0	15	14	23	8	60	*87*	24	3	15	10	0	17	8	16	11	52
Cullen	18	17	95	68	1	22	19	108	50	199	*85*	21	17	121	24	0	13	36	97	37	183
Deskford	11	2	28	15	1	10	9	25	13	57	*86*	10	4	20	11	1	6	13	13	14	46
Enzie	62	17	89	35	2	11	71	88	35	205	*87*	82	10	85	31	0	16	77	88	27	208
Fordyce	135	18	181	125	2	64	129	162	106	461	*85*	131	23	170	125	9	44	120	174	120	458
Gamrie	133	28	155	79	0	2	135	156	102	395	*85*	139	25	174	102	0	5	149	139	147	440
Glenrinnes	3	2	14	9	0	13	10	2	3	28	*90*	12	3	9	11	2	11	15	6	5	37
Grange	15	3	13	8	0	7	13	10	9	39	*87*	13	2	12	10	1	6	10	15	7	38
Inveravon	51	15	53	74	9	46	54	58	44	202	*91*	59	11	47	55	6	43	54	35	46	178
Inverkeithny	12	7	19	21	1	4	25	17	14	60	*87*	22	6	21	7	0	6	24	11	15	56
Keith	105	29	125	86	2	52	79	115	101	347	*87*	137	28	157	92	6	70	121	130	99	420
Kirkmichael	6	0	4	8	2	0	5	10	5	20	*91*	5	2	5	4	1	0	6	8	3	17
Marnoch	77	17	87	54	4	57	40	74	68	239	*86*	111	19	76	66	4	78	50	88	60	276
Mortlach	76	19	103	43	3	49	92	48	55	244	*90*	85	21	105	38	3	60	66	69	57	252
Ordiquhill	12	7	39	19	4	26	23	13	19	81	*86*	21	4	34	22	1	28	25	16	13	82
Rathven (and Buckie) ...	193	76	415	198	9	105	266	299	221	891	*85*	262	60	349	211	2	109	272	294	209	884
Rothiemay	29	4	68	49	0	11	33	64	42	150	*87*	34	7	66	37	0	32	32	52	28	144
Totals	1250	325	2047	1147	55	734	1335	1626	1129	4824	—	1499	336	1944	1103	46	761	1398	1622	1147	4928
BERWICK.																					
Abbey St Bathan's	5	1	5	12	0	0	8	7	8	23	*42*	8	1	4	11	0	0	10	5	9	24
Ayton	22	2	10	13	1	2	13	20	13	48	*42*	19	0	12	7	1	5	14	9	11	39
Bunkle and Preston ...	4	0	7	4	0	3	2	9	1	15	*42*	11	0	6	2	0	6	5	6	2	19
Channelkirk	10	1	23	6	0	5	6	21	8	40	*42*	10	3	11	8	0	3	4	20	5	32
Chirnside	32	2	64	16	0	4	58	37	15	114	*42*	27	5	46	27	0	0	48	45	12	105
Cockburnspath	3	0	6	9	0	4	7	3	4	18	*42*	4	0	4	3	0	3	4	1	3	11
Coldingham	89	14	71	44	2	61	70	61	28	220	*42*	93	7	69	44	0	50	72	61	30	213
Coldstream	54	2	64	43	2	16	51	55	43	165	*42*	34	5	51	28	0	10	38	45	25	118
Cranshaws	0	0	2	9	0	0	6	4	1	11	*42*	0	0	6	3	0	0	4	4	1	9
Duns	9	4	22	9	0	6	18	14	6	44	*42*	5	3	16	7	0	4	9	6	12	31
Earlston	2	0	0	2	1	1	1	0	3	5	*42*	3	0	2	1	0	1	2	0	3	6
Eccles	17	5	15	4	0	17	6	16	2	41	*42*	14	5	25	10	0	23	10	9	12	54
Edrom	10	2	19	12	0	8	9	8	18	43	*42*	10	0	15	4	0	3	10	6	10	29
Foulden	12	0	13	6	0	10	7	9	5	31	*42*	9	0	5	8	0	4	14	2	2	22
Gordon	17	3	29	21	0	8	30	19	13	70	*42*	27	3	18	11	0	11	17	19	12	59
Hume and Stitchell ...	16	3	26	8	0	7	25	15	6	53	*42*	18	1	17	7	2	5	22	9	9	45
Hutton	23	9	21	13	2	15	21	14	18	68	*42*	31	2	14	12	2	17	20	13	11	61
Ladykirk	8	1	7	5	0	0	14	5	2	21	*42*	9	4	8	8	0	1	16	12	0	29
Langton	8	1	15	4	0	7	14	0	7	28	*42*	8	3	7	3	0	5	12	0	4	21
Lauder	43	3	29	19	0	11	38	24	21	94	*42*	25	6	26	12	1	3	32	20	15	70
Legerwood	10	2	6	9	2	8	15	4	2	29	*42*	11	2	16	10	0	7	15	11	6	39
Longformacus	4	0	6	1	0	5	2	3	1	11	*42*	7	0	4	1	0	8	0	3	1	12
Mertoun	9	4	15	12	4	4	13	17	10	44	*39*	7	2	10	12	0	3	5	11	12	31

TABLE XV.—(*continued*).

County and Parish Data.

AYR—(*continued*).

Parish	BOYS										District	GIRLS									
	Hair					Eyes				Totals		Hair					Eyes				Totals
	Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark			Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark	
Kirkoswald	12	2	26	5	1	0	14	20	12	46	*31*	14	1	17	11	0	3	14	15	11	43
Largs	17	1	26	8	2	5	12	29	8	54	*23*	22	1	20	11	2	7	13	26	10	56
Loudoun	132	20	162	90	16	190	96	69	65	420	*28*	173	23	140	105	9	179	103	74	94	450
Mauchline	61	4	183	64	1	27	85	135	66	313	*26*	79	4	161	62	0	29	103	114	60	306
Maybole & Maybole W. Church	140	33	307	243	5	64	160	307	197	728	*31*	138	27	264	177	6	60	135	261	156	612
Monkton and Prestwick ...	74	12	106	24	2	19	14	106	49	218	*26*	70	12	92	31	4	25	53	96	38	212
Muirkirk	30	4	49	47	2	10	29	51	42	132	*26*	39	5	48	37	3	26	34	39	33	132
New Cumnock	104	31	118	85	2	89	106	85	60	340	*36*	128	16	108	90	0	78	110	91	63	342
Ochiltree	38	6	65	51	0	15	45	56	44	160	*26*	38	7	49	42	3	12	35	48	44	139
Old Cumnock	144	36	159	128	4	126	111	145	89	471	*26*	166	23	146	119	3	96	129	146	86	457
Riccarton	117	22	145	118	10	52	134	160	66	412	*28*	135	18	134	118	1	70	113	162	61	406
St Quivox (Landward) and Newton on Ayr (Landward)	13	1	24	12	8	12	14	22	10	58	*26*	9	0	24	5	1	8	9	18	4	39
Sorn	109	11	105	46	1	54	86	88	44	272	*26*	94	19	81	51	1	42	73	77	54	246
Stair	36	3	33	18	1	13	39	21	18	91	*26*	47	8	34	18	3	26	39	29	16	110
Stevenston	247	45	351	212	7	259	191	203	209	862	*29*	244	33	349	202	20	249	192	212	195	848
Stewarton	112	14	99	42	1	137	34	55	42	268	*30*	123	15	97	49	3	146	36	45	60	287
Straiton	16	3	12	11	0	14	7	7	14	42	*31*	16	0	6	12	0	14	9	1	10	34
Symington	16	3	3	13	4	16	5	7	11	39	*26*	19	1	9	8	2	21	6	6	6	39
Tarbolton	60	4	95	39	2	82	42	32	44	200	*26*	60	10	90	23	1	95	32	29	28	184
West Kilbride	32	8	93	34	3	23	58	60	29	170	*23*	40	10	90	65	5	29	73	62	46	210
Totals	4476	893	6977	4116	203	2748	5238	5125	3554	16665	—	4687	795	6483	3837	171	2708	4911	4960	3394	15973
BANFF.																					
Aberlour	71	21	86	77	9	84	64	43	73	264	*90*	84	27	75	66	4	70	63	62	61	256
Alvah	15	5	34	11	0	23	10	17	15	65	*86*	20	7	26	13	1	23	12	19	13	67
Banff (Burgh)	81	20	218	68	3	79	93	135	83	390	*85*	92	31	185	84	2	77	83	155	79	394
„ (Landward) and Ord ...	22	3	25	26	2	10	36	23	9	78	*85*	26	5	30	26	1	12	28	26	22	88
Bellie	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Boharm	23	4	42	18	1	15	32	26	15	88	*90*	26	8	33	24	1	17	21	29	25	92
Botriphnie	28	2	24	7	0	7	23	24	7	61	*87*	26	4	19	9	0	2	29	13	14	58
Boyndie	49	4	112	35	0	22	60	86	32	200	*85*	57	9	110	25	1	16	84	67	35	202
Cabrach	23	5	18	14	0	15	14	23	8	60	*87*	24	3	15	10	0	17	8	16	11	52
Cullen	18	17	95	68	1	22	19	108	50	199	*85*	21	17	121	24	0	13	36	97	37	183
Deskford	11	2	28	15	1	10	9	25	13	57	*86*	10	4	20	11	1	6	13	13	14	46
Enzie	62	17	89	35	2	11	71	88	35	205	*87*	82	10	85	31	0	16	77	88	27	208
Fordyce	135	18	181	125	2	64	129	162	106	461	*85*	131	23	170	125	9	44	120	174	120	458
Gamrie	133	28	155	79	0	2	135	156	102	395	*85*	139	25	174	102	0	5	149	139	147	440
Glenrinnes	3	2	14	9	0	13	10	2	3	28	*90*	12	3	9	11	2	11	15	6	5	37
Grange	15	3	13	8	0	7	13	10	9	39	*87*	13	2	12	10	1	6	10	15	7	38
Inveravon	51	15	53	74	9	46	54	58	44	202	*91*	59	11	47	55	6	43	54	35	46	178
Inverkeithny	12	7	19	21	1	4	25	17	14	60	*87*	22	6	21	7	0	6	24	11	15	56
Keith	105	29	125	86	2	52	79	115	101	347	*87*	137	28	157	92	6	70	121	130	99	420
Kirkmichael	6	0	4	8	2	0	5	10	5	20	*91*	5	2	5	4	1	0	6	8	3	17
Marnoch	77	17	87	54	4	57	40	74	68	239	*86*	111	19	76	66	4	78	50	88	60	276
Mortlach	76	19	103	43	3	49	92	48	55	244	*90*	85	21	105	38	3	60	66	69	57	252
Ordiquhill	12	7	39	19	4	26	23	13	19	81	*86*	21	4	34	22	1	28	25	16	13	82
Rathven (and Buckie) ...	193	76	415	198	9	105	266	299	221	891	*87*	262	60	349	211	2	109	272	294	209	884
Rothiemay	29	4	68	49	0	11	33	64	42	150	*87*	34	7	66	37	0	32	32	52	28	144
Totals	1250	325	2047	1147	55	734	1335	1626	1129	4824	—	1499	336	1944	1103	46	761	1398	1622	1147	4928
BERWICK.																					
Abbey St Bathan's	5	1	5	12	0	0	8	7	8	23	*42*	8	1	4	11	0	0	10	5	9	24
Ayton	22	2	10	13	1	2	13	20	13	48	*42*	19	0	12	7	1	5	14	9	11	39
Bunkle and Preston ...	4	0	7	4	0	3	2	9	1	15	*42*	11	0	6	2	0	6	5	6	2	19
Channelkirk	10	1	23	6	0	5	6	21	8	40	*42*	10	3	11	8	0	3	4	20	5	32
Chirnside	32	2	64	16	0	4	58	37	15	114	*42*	27	5	46	27	0	0	48	45	12	105
Cockburnspath	3	0	6	9	0	4	7	3	4	18	*42*	4	0	4	3	0	3	4	1	3	11
Coldingham	89	14	71	44	2	61	70	61	28	220	*42*	93	7	69	44	0	50	72	61	30	213
Coldstream	54	2	64	43	2	16	51	55	43	165	*42*	34	5	51	28	0	10	38	45	25	118
Cranshaws	0	0	2	9	0	0	6	4	1	11	*42*	0	0	6	3	0	0	4	4	1	9
Duns	9	4	22	9	0	6	18	14	6	44	*42*	5	3	16	7	0	4	9	6	12	31
Earlston	2	0	0	2	1	1	1	0	3	5	*42*	3	0	2	1	0	1	2	0	3	6
Eccles	17	5	15	4	0	17	6	16	2	41	*42*	14	5	25	10	0	23	10	9	12	54
Edrom	10	2	19	12	0	8	9	8	18	43	*42*	10	0	15	4	0	3	10	6	10	29
Foulden	12	0	13	6	0	10	7	9	5	31	*42*	9	0	5	8	0	4	14	2	2	22
Gordon	17	3	29	21	0	8	30	19	13	70	*42*	27	3	18	11	0	11	17	19	12	59
Hume and Stitchell ...	16	3	26	8	0	7	25	15	6	53	*42*	18	1	17	7	2	5	22	9	9	45
Hutton	23	9	21	13	2	15	21	14	18	68	*42*	31	2	14	12	2	17	20	13	11	61
Ladykirk	8	1	7	5	0	0	14	5	2	21	*42*	9	4	8	8	0	1	16	12	0	29
Langton	8	1	15	4	0	7	14	0	7	28	*42*	8	3	7	3	0	5	12	0	4	21
Lauder	43	3	29	19	0	11	38	24	21	94	*42*	25	6	26	12	1	3	32	20	15	70
Legerwood	10	2	6	9	2	8	15	4	2	29	*42*	11	2	16	10	0	7	15	11	6	39
Longformacus	4	0	6	1	0	5	2	3	1	11	*42*	7	0	4	1	0	8	0	3	1	12
Mertoun	9	4	15	12	4	4	13	17	10	44	*39*	7	2	10	12	0	3	5	11	12	31

TABLE XV.—(*continued*).

County and Parish Data.

BERWICK—(*continued*).

Parish	BOYS Hair Fair	Red	Medium	Dark	Jet Black	Eyes Blue	Light	Medium	Dark	Totals	District	GIRLS Hair Fair	Red	Medium	Dark	Jet Black	Eyes Blue	Light	Medium	Dark	Totals
Mordington	6	3	3	4	0	6	1	4	5	16	*42*	7	4	8	5	0	10	2	6	6	24
Nenthorn	3	1	15	5	0	4	10	5	5	24	*42*	0	2	9	12	0	4	4	9	6	23
Polwarth	3	1	6	12	3	0	6	12	7	25	*42*	3	1	9	2	0	1	6	7	1	15
Swinton	13	1	25	33	2	8	19	26	21	74	*42*	18	3	32	17	2	7	19	26	20	72
Westruther	16	6	8	20	2	14	11	14	13	52	*42*	18	2	9	8	2	9	15	7	8	39
Whitsome	14	1	22	7	1	4	19	9	13	45	*42*	14	2	18	20	2	8	13	15	20	56
Totals	462	72	554	362	22	238	500	435	299	1472	—	450	66	477	303	12	211	442	387	268	1308
BUTE.																					
Cumbrae	22	7	49	22	2	9	36	29	28	102	*104*	25	10	47	13	0	9	34	25	27	95
Kilbride	18	1	61	47	0	13	21	68	25	127	*103*	30	2	69	40	1	14	33	61	34	142
Kilmory	10	1	39	32	4	12	40	16	18	86	*103*	25	0	16	21	1	6	35	8	14	63
Kingarth	17	7	34	28	5	6	40	26	19	91	*104*	12	5	26	22	2	5	35	13	14	67
North Bute	10	9	49	30	3	18	27	35	21	101	*104*	14	1	26	28	1	10	18	25	17	70
Rothesay (Burgh) ...	156	46	335	153	11	66	243	238	154	701	*104*	200	46	281	206	10	96	242	269	136	743
Totals	233	71	567	312	25	124	407	412	265	1208	—	306	64	465	330	15	140	397	401	242	1180
CAITHNESS.																					
Bower	15	2	49	33	1	27	13	39	21	100	*98*	39	4	50	15	3	39	26	28	18	111
Canisbay	37	7	62	35	2	24	36	59	24	143	*97*	57	8	53	30	2	16	54	47	33	150
Dunnet	31	9	48	11	0	19	25	40	15	99	*98*	27	3	42	11	0	17	19	31	16	83
Halkirk	47	9	54	36	6	35	44	40	33	152	*98*	64	4	43	33	3	24	39	46	38	147
Keiss...	7	7	15	9	0	6	10	13	9	38	*97*	11	3	7	2	0	11	3	4	5	23
Latheron	84	11	79	58	1	23	93	68	49	233	*97*	75	8	65	48	3	22	76	66	35	199

Olrig	38	6	61	58	2	36	49	34	46	165	*98*	41	8	64	25	1	23	46	38	32	139
Reay	8	5	30	6	1	3	3	32	12	50	*98*	9	1	18	6	0	2	9	14	9	34
Thurso	54	27	266	126	2	30	175	149	121	475	*98*	59	24	264	142	2	37	174	147	133	491
Watten	29	7	28	20	3	5	36	28	18	87	*98*	40	2	13	29	3	4	28	22	33	87
Wick (Burgh)... ...	279	67	394	305	46	116	244	430	301	1091	*97*	262	44	330	263	30	111	252	329	237	929
Wick (Landward) ...	82	12	55	47	4	37	77	44	42	200	*97*	60	8	47	43	3	51	49	26	35	161
Totals	711	169	1141	744	68	361	805	976	691	2833	—	744	117	996	647	50	357	775	798	624	2554

CLACKMANNAN.

Alloa (Town)... ...	236	44	435	188	0	56	339	331	177	903	*51*	243	36	401	182	1	64	350	291	158	863
„ (Landward) ...	59	6	54	31	0	72	35	15	28	150	*51*	56	0	45	19	1	53	35	12	21	121
Alva	25	6	34	9	1	36	4	27	8	75	*51*	11	2	4	2	1	12	0	5	3	20
Clackmannan	38	2	117	77	2	25	60	87	64	236	*51*	64	6	79	60	1	25	48	77	60	210
Dollar...	32	4	43	26	1	23	47	16	20	106	*51*	16	6	30	29	0	16	22	28	15	81
Tillicoultry	103	25	161	138	2	33	142	163	91	429	*51*	95	17	147	102	0	25	106	142	88	361
Totals	493	87	844	469	6	245	627	639	388	1899	—	485	67	706	394	4	195	561	555	345	1656

DUMBARTON.

Arrochar	6	1	17	5	0	1	8	15	5	29	*101*	4	1	18	12	0	0	6	20	9	35
Bonhill	344	48	401	320	16	188	381	273	287	1129	*105*	342	35	363	370	16	172	389	306	259	1126
Cardross	105	29	198	123	6	53	163	177	68	461	*105*	87	16	157	89	1	30	115	118	87	350
Cumbernauld	42	12	136	61	3	25	99	64	66	254	*10*	38	12	107	62	1	15	85	67	53	220
Dumbarton (Burgh) ...	288	35	433	226	10	86	323	379	204	992	*106*	294	29	388	213	3	68	330	328	201	927
Kilmaronock ...	18	0	13	10	1	18	5	16	3	42	*105*	20	0	5	21	1	20	7	16	4	47
Kirkintilloch (Town)...	95	27	141	106	3	66	127	109	70	372	*12*	98	29	128	106	11	78	124	101	69	372
„ (Land.)...	79	11	77	55	6	23	109	56	40	228	*12*	74	19	86	44	11	27	95	55	57	234
Luss	13	1	17	15	0	2	13	19	12	46	*105*	12	1	15	10	2	7	19	8	6	40
New or E. Kilpatrick...	65	21	158	51	0	21	116	110	48	295	*19*	70	19	158	63	0	41	129	97	43	310
Old or W. Kilpatrick...	157	32	311	190	17	105	204	220	178	707	*22*	184	32	290	169	9	87	227	202	168	684
Roseneath	15	0	15	20	2	4	29	16	3	52	*105*	11	1	7	15	1	6	18	10	1	35
Row	181	33	271	156	13	147	159	161	187	654	*105*	188	20	218	152	13	128	185	142	136	591
Totals	1408	250	2188	1338	77	739	1736	1615	1171	5261	—	1422	214	1940	1326	69	679	1729	1470	1093	4971

TABLE XV.—(*continued*).

County and Parish Data.

BERWICK—(*continued*).

Parish	BOYS											GIRLS									
	Hair					Eyes				Totals	District	Hair					Eyes				Totals
	Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark			Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark	
Mordington	6	3	3	4	0	6	1	4	5	16	*42*	7	4	8	5	0	10	2	6	6	24
Nenthorn	3	1	15	5	0	4	10	5	5	24	*42*	0	2	9	12	0	4	4	9	6	23
Polwarth	3	1	6	12	3	0	6	12	7	25	*42*	3	1	9	2	0	1	6	7	1	15
Swinton	13	1	25	33	2	8	19	26	21	74	*42*	18	3	32	17	2	7	19	26	20	72
Westruther	16	6	8	20	2	14	11	14	13	52	*42*	18	2	9	8	2	9	15	7	8	39
Whitsome	14	1	22	7	1	4	19	9	13	45	*42*	14	2	18	20	2	8	13	15	20	56
Totals	462	72	554	362	22	238	500	435	299	1472	—	450	66	477	303	12	211	442	387	268	1308
BUTE.																					
Cumbrae	22	7	49	22	2	9	36	29	28	102	*104*	25	10	47	13	0	9	34	25	27	95
Kilbride	18	1	61	47	0	13	21	68	25	127	*103*	30	2	69	40	1	14	33	61	34	142
Kilmory	10	1	39	32	4	12	40	16	18	86	*103*	25	0	16	21	1	6	35	8	14	63
Kingarth	17	7	34	28	5	6	40	26	19	91	*104*	12	5	26	22	2	5	35	13	14	67
North Bute	10	9	49	30	3	18	27	35	21	101	*104*	14	1	26	28	1	10	18	25	17	70
Rothesay (Burgh)	156	46	335	153	11	66	243	238	154	701	*104*	200	46	281	206	10	96	242	269	136	743
Totals	233	71	567	312	25	124	407	412	265	1208	—	306	64	465	330	15	140	397	401	242	1180
CAITHNESS.																					
Bower	15	2	49	33	1	27	13	39	21	100	*98*	39	4	50	15	3	39	26	28	18	111
Canisbay	37	7	62	35	2	24	36	59	24	143	*97*	57	8	53	30	2	16	54	47	33	150
Dunnet	31	9	48	11	0	19	25	40	15	99	*98*	27	3	42	11	0	17	19	31	16	83
Halkirk	47	9	54	36	6	35	44	40	33	152	*98*	64	4	43	33	3	24	39	46	38	147
Keiss...	7	7	15	9	0	6	10	13	9	38	*97*	11	3	7	2	0	11	3	4	5	23
Latheron	84	11	79	58	1	23	93	68	49	233	*97*	75	8	65	48	3	22	76	66	35	199
Olrig	38	6	61	58	2	36	49	34	46	165	*98*	41	8	64	25	1	23	46	38	32	139
Reay	8	5	30	6	1	3	3	32	12	50	*98*	9	1	18	6	0	2	9	14	9	34
Thurso	54	27	266	126	2	30	175	149	121	475	*98*	59	24	264	142	2	37	174	147	133	491
Watten	29	7	28	20	3	5	36	28	18	87	*98*	40	2	13	29	3	4	28	22	33	87
Wick (Burgh)...	279	67	394	305	46	116	244	430	301	1091	*97*	262	44	330	263	30	111	252	329	237	929
Wick (Landward)	82	12	55	47	4	37	77	44	42	200	*97*	60	8	47	43	3	51	49	26	35	161
Totals	711	169	1141	744	68	361	805	976	691	2833	—	744	117	996	647	50	357	775	798	624	2554
CLACKMANNAN.																					
Alloa (Town)...	236	44	435	188	0	56	339	331	177	903	*51*	243	36	401	182	1	64	350	291	158	863
,, (Landward)	59	6	54	31	0	72	35	15	28	150	*51*	56	0	45	19	1	53	35	12	21	121
Alva	25	6	34	9	1	36	4	27	8	75	*51*	11	2	4	2	1	12	0	5	3	20
Clackmannan	38	2	117	77	2	25	60	87	64	236	*51*	64	6	79	60	1	25	48	77	60	210
Dollar...	32	4	43	26	1	23	47	16	20	106	*51*	16	6	30	29	0	16	22	28	15	81
Tillicoultry	103	25	161	138	2	33	142	163	91	429	*51*	95	17	147	102	0	25	106	142	88	361
Totals	493	87	844	469	6	245	627	639	388	1899	—	485	67	706	394	4	195	561	555	345	1656
DUMBARTON.																					
Arrochar	6	1	17	5	0	1	8	15	5	29	*101*	4	1	18	12	0	0	6	20	9	35
Bonhill	344	48	401	320	16	188	381	273	287	1129	*105*	342	35	363	370	16	172	389	306	259	1126
Cardross	105	29	198	123	6	53	163	177	68	461	*105*	87	16	157	89	1	30	115	118	87	350
Cumbernauld	42	12	136	61	3	25	99	64	66	254	*10*	38	12	107	62	1	15	85	67	53	220
Dumbarton (Burgh)	288	35	433	226	10	86	323	379	204	992	*106*	294	29	388	213	3	68	330	328	201	927
Kilmaronock	18	0	13	10	1	18	5	16	3	42	*105*	20	0	5	21	1	20	7	16	4	47
Kirkintilloch (Town)...	95	27	141	106	3	66	127	109	70	372	*12*	98	29	128	106	11	78	124	101	69	372
,, (Land.)...	79	11	77	55	6	23	109	56	40	228	*12*	74	19	86	44	11	27	95	55	57	234
Luss	13	1	17	15	0	2	13	19	12	46	*105*	12	1	15	10	2	7	19	8	6	40
New or E. Kilpatrick...	65	21	158	51	0	21	116	110	48	295	*19*	70	19	158	63	0	41	129	97	43	310
Old or W. Kilpatrick...	157	32	311	190	17	105	204	220	178	707	*22*	184	32	290	169	9	87	227	202	168	684
Roseneath	15	0	15	20	2	4	29	16	3	52	*105*	11	1	7	15	1	6	18	10	1	35
Row	181	33	271	156	13	147	159	161	187	654	*105*	188	20	218	152	13	128	185	142	136	591
Totals	1408	250	2188	1338	77	739	1736	1615	1171	5261	—	1422	214	1940	1326	69	679	1729	1470	1093	4971

TABLE XV.—(*continued*).

County and Parish Data.

DUMFRIES.

Parish	BOYS										District	GIRLS									
	HAIR					EYES				Totals		HAIR					EYES				Totals
	Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark			Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark	
Annan	174	23	264	163	4	123	120	236	149	628	*37*	175	30	236	118	7	111	128	188	139	566
Applegarth & Sibbaldbie	7	2	35	15	0	10	12	17	20	59	*37*	17	1	13	7	0	8	9	15	6	38
Brydekirk	15	0	20	15	0	17	9	15	9	50	*37*	26	3	34	26	2	23	27	18	23	91
Canonbie	32	3	16	22	0	13	26	21	13	73	*37*	38	4	20	17	1	13	33	18	16	80
Caerlaverock	10	5	9	8	0	6	11	12	3	32	*37*	8	1	9	9	1	8	6	8	6	28
Closeburn	25	8	64	36	0	8	66	29	30	133	*36*	49	9	64	40	0	17	53	55	37	162
Cummertrees	9	1	7	7	0	0	7	3	14	24	*35*	9	0	6	5	1	4	5	0	12	21
Dalton	10	2	17	9	0	7	12	9	10	38	*37*	15	1	15	5	0	11	12	9	4	36
Dornock	19	2	32	21	0	25	10	10	29	74	*37*	16	4	37	19	0	18	14	15	29	76
Dryfesdale	78	18	172	44	1	57	116	95	45	313	*37*	62	17	189	56	4	62	102	108	56	328
Dumfries (Burgh) ...	253	54	524	221	9	73	375	418	195	1061	*35*	214	30	371	207	7	69	308	281	171	829
,, (Landward)	101	23	169	98	4	63	134	117	81	395	*35*	115	23	157	97	1	59	129	128	77	393
Dunscore	24	3	19	34	8	15	35	20	18	88	*36*	17	2	26	24	10	15	21	31	12	79
Durrisdeer	22	0	14	25	2	8	24	16	15	63	*36*	37	3	29	17	1	11	39	25	12	87
Eskdalemuir	4	1	4	3	0	0	2	8	2	12	*37*	6	2	7	4	0	0	8	7	4	19
Ewes	3	5	12	0	0	0	13	7	0	20	*37*	2	1	7	1	0	0	5	3	3	11
Glencairn	27	5	30	29	1	15	47	16	14	92	*36*	50	2	27	16	1	15	46	21	14	96
Gretna	32	5	29	32	0	2	25	43	28	98	*37*	44	7	31	25	2	3	40	41	25	109
Hoddam	26	5	57	28	0	6	60	31	19	116	*37*	48	2	32	23	1	16	53	15	22	106
Holywood	36	5	51	23	1	4	26	69	17	116	*36*	32	5	23	12	2	1	14	41	18	74
Hutton and Corrie ...	13	3	57	8	0	22	27	23	9	81	*37*	10	3	45	9	0	12	26	24	5	67
Johnstone	20	4	34	10	0	0	35	21	12	68	*37*	26	9	28	7	1	1	38	22	10	71
Keir	10	2	23	5	1	12	14	6	9	41	*36*	8	4	15	4	0	3	17	6	5	31
Kirkconnel	1	1	1	0	1	0	2	2	0	4	*36*	4	0	4	3	1	1	3	3	5	12
Kirkmahoe	10	0	10	10	0	2	16	7	5	30	*36*	5	0	9	7	0	5	6	8	2	21
Kirkmichael	13	1	29	16	1	7	24	22	7	60	*37*	17	5	17	19	2	5	20	18	17	60
Kirkpatrick Fleming ...	38	3	72	40	0	10	40	78	25	153	*37*	31	3	44	33	2	7	33	49	24	113
,, Juxta ...	17	4	27	11	1	21	16	10	13	60	*37*	36	5	17	9	1	18	24	8	18	68
Langholm	74	15	149	65	2	26	97	100	82	305	*37*	93	9	98	69	3	27	78	99	68	272
Lochmaben	96	6	88	45	0	38	76	89	32	235	*37*	113	6	75	43	0	32	76	104	25	237
Middlebie	40	6	51	32	1	17	39	47	27	130	*37*	46	8	45	42	0	23	29	56	33	141
Moffat	47	6	140	62	1	49	57	108	42	256	*37*	57	9	117	50	2	50	53	83	49	235
Morton	29	6	27	15	0	4	26	28	19	77	*36*	34	7	24	17	0	4	19	37	22	82
Mouswald	9	1	5	9	2	4	7	11	4	26	*35*	10	1	3	8	1	3	12	7	1	23
Penpont	13	4	37	10	0	9	27	23	5	64	*36*	14	6	34	10	1	7	21	31	6	65

St Mungo	15	6	9	12	0	27	4	2	9	42	*37*	22	1	17	11	0	24	7	6	14	51
Sanquhar	65	10	118	71	0	7	94	89	74	264	*36*	62	13	92	62	4	5	91	87	50	233
Tinwald	22	4	13	19	0	4	20	24	10	58	*37*	16	5	14	29	1	10	25	17	13	65
Torthorwald	39	4	13	35	1	16	28	40	8	92	*35*	29	7	15	33	3	10	20	36	21	87
Tundergarth	12	1	18	15	0	0	26	3	17	46	*37*	17	1	19	13	0	0	30	7	13	50
Tynron	4	3	14	5	0	6	6	10	4	26	*36*	16	0	11	2	0	5	8	12	4	29
Wamphray	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Westerkirk	9	2	22	8	2	12	15	6	10	43	*37*	12	2	9	9	0	5	14	3	10	32
Totals	1503	262	2502	1336	43	745	1826	1941	1134	5646	—	1658	251	2085	1217	63	721	1702	1750	1101	5274

EDINBURGH.

Borthwick	34	2	16	11	2	18	16	21	10	65	*47*	31	8	19	7	1	21	23	12	10	66
Carrington	10	0	3	7	0	2	10	0	8	20	*47*	9	3	5	6	1	3	12	0	9	24
Cockpen	28	9	82	49	2	19	65	56	30	170	*47*	45	8	62	30	2	17	53	56	21	147
Coliuton	84	21	184	78	3	75	124	106	65	370	*46*	85	18	147	75	3	60	79	116	73	328
Corstorphine	65	12	65	52	2	28	57	76	35	196	*46*	43	10	59	38	2	7	62	53	30	152
Cramond	32	10	64	44	4	18	54	47	35	154	*46*	47	8	60	18	2	14	65	26	30	135
Cranston	40	3	40	22	1	31	32	31	12	106	*47*	46	2	36	13	0	16	38	34	9	97
Crichton	14	1	57	21	1	19	31	31	13	94	*47*	23	0	41	20	3	22	28	19	18	87
Currie	45	11	83	42	1	15	53	72	42	182	*46*	51	9	72	36	0	20	45	57	46	168
Dalkeith (Town) ...	61	18	160	75	2	27	139	89	61	316	*47*	85	17	140	56	1	15	125	101	58	299
Edinburgh City ...	2584	529	4220	2388	98	1484	2927	2992	2416	9819	*44*	2593	485	4008	2518	139	1437	2908	2996	2402	9743
Fala and Soutra ...	8	1	22	3	0	0	15	18	1	34	*47*	14	2	11	8	0	0	13	17	5	35
Glencorse	28	5	57	17	0	27	35	22	23	107	*47*	45	6	49	32	0	32	36	23	41	132
Heriot	5	3	13	11	0	2	0	18	12	32	*47*	8	0	15	11	0	0	0	18	16	34
Inveresk (Landward)	35	8	28	20	0	16	29	26	20	91	*46*	32	10	23	13	0	14	24	25	15	78
Kirknewton & E. Calder	65	16	95	82	6	13	84	99	68	264	*47*	91	12	125	61	2	34	89	111	57	291
Lasswade	244	41	437	181	6	221	212	282	194	909	*47*	270	66	395	164	7	183	243	283	193	902
Leith Burgh	1365	343	2630	1411	42	611	1888	1978	1314	5791	*45*	1602	289	2443	1448	36	642	1913	2009	1254	5818
Liberton	117	23	168	82	8	74	93	120	111	398	*46*	110	22	150	61	1	66	89	102	87	344
Mid-Calder	25	2	18	27	0	5	33	17	17	72	*47*	24	3	25	17	0	5	23	23	18	69
Musselburgh	219	42	361	185	3	127	284	229	170	810	*46*	275	50	385	219	4	142	280	325	186	933
Newbattle	2	2	17	10	0	13	4	6	8	31	*47*	7	1	11	3	0	7	1	7	7	22
Penicuik	54	14	109	57	1	26	44	94	71	235	*47*	59	13	95	48	2	21	62	89	45	217
Ratho	46	10	71	28	1	25	49	57	25	156	*46*	41	11	44	33	2	25	50	32	24	131
Stobhill	116	28	144	60	3	78	103	104	66	351	*47*	101	19	158	57	4	81	85	101	72	339
Temple	20	3	19	17	0	29	5	7	18	59	*47*	23	4	12	8	0	23	5	12	7	47
West Calder	41	12	54	45	0	41	30	44	37	152	*47*	62	8	66	33	0	50	47	40	32	169
Totals	5387	1169	9217	5025	186	3044	6416	6642	4882	20984	—	5822	1084	8656	5033	212	2957	6398	6687	4765	20807

TABLE XV.—(*continued*).

County and Parish Data.

DUMFRIES.

Parish	BOYS										District	GIRLS									
	Hair					Eyes				Totals		Hair					Eyes				Totals
	Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark			Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark	
Annan	174	23	264	163	4	123	120	236	149	628	37	175	30	236	118	7	111	128	188	139	566
Applegarth & Sibbaldbie	7	2	35	15	0	10	12	17	20	59	37	17	1	13	7	0	8	9	15	6	38
Brydekirk	15	0	20	15	0	17	9	15	9	50	37	26	3	34	26	2	23	27	18	23	91
Canonbie	32	3	16	22	0	13	26	21	13	73	37	38	4	20	17	1	13	33	18	16	80
Caerlaverock	10	5	9	8	0	6	11	12	3	32	37	8	1	9	9	1	8	6	8	6	28
Closeburn	25	8	64	36	0	8	66	29	30	133	36	49	9	64	40	0	17	53	55	37	162
Cummertrees	9	1	7	7	0	0	7	3	14	24	35	9	0	6	5	1	4	5	0	12	21
Dalton	10	2	17	9	0	7	12	9	10	38	37	15	1	15	5	0	11	12	9	4	36
Dornock	19	2	32	21	0	25	10	10	29	74	37	16	4	37	19	0	18	14	15	29	76
Dryfesdale	78	18	172	44	1	57	116	95	45	313	37	62	17	189	56	4	62	102	108	56	328
Dumfries (Burgh) ...	253	54	524	221	9	73	375	418	195	1061	35	214	30	371	207	7	69	308	281	171	829
,, (Landward)	101	23	169	98	4	63	134	117	81	395	35	115	23	157	97	1	59	129	128	77	393
Dunscore	24	3	19	34	8	15	35	20	18	88	36	17	2	26	24	10	15	21	31	12	79
Durrisdeer	22	0	14	25	2	8	24	16	15	63	36	37	3	29	17	1	11	39	25	12	87
Eskdalemuir	4	1	4	3	0	0	2	8	2	12	37	6	2	7	4	0	0	8	7	4	19
Ewes	3	5	12	0	0	0	13	7	0	20	37	2	1	7	1	0	0	5	3	3	11
Glencairn	27	5	30	29	1	15	47	16	14	92	36	50	2	27	16	1	15	46	21	14	96
Gretna	32	5	29	32	0	2	25	43	28	98	37	44	7	31	25	2	3	40	41	25	109
Hoddam	26	5	57	28	0	6	60	31	19	116	37	48	2	32	23	1	16	53	15	22	106
Holywood	36	5	51	23	1	4	26	69	17	116	36	32	5	23	12	2	1	14	41	18	74
Hutton and Corrie ...	13	3	57	8	0	22	27	23	9	81	37	10	3	45	9	0	12	26	24	5	67
Johnstone	20	4	34	10	0	0	35	21	12	68	37	26	9	28	7	1	1	38	22	10	71
Keir	10	2	23	5	1	12	14	6	9	41	36	8	4	15	4	0	3	17	6	5	31
Kirkconnel	1	1	1	0	1	0	2	2	0	4	36	4	0	4	3	1	1	3	3	5	12
Kirkmahoe	10	0	10	10	0	2	16	7	5	30	36	5	0	9	7	0	5	6	8	2	21
Kirkmichael	13	1	29	16	1	7	24	22	7	60	37	17	5	17	19	2	5	20	18	17	60
Kirkpatrick Fleming ...	38	3	72	40	0	10	40	78	25	153	37	31	3	44	33	2	7	33	49	24	113
,, Juxta ...	17	4	27	11	1	21	16	10	13	60	37	36	5	17	9	1	18	24	8	18	68
Langholm	74	15	149	65	2	26	97	100	82	305	37	93	9	98	69	3	27	78	99	68	272
Lochmaben	96	6	88	45	0	38	76	89	32	235	37	113	6	75	43	0	32	76	104	25	237
Middlebie	40	6	51	32	1	17	39	47	27	130	37	46	8	45	42	0	23	29	56	33	141
Moffat	47	6	140	62	1	49	57	108	42	256	37	57	9	117	50	2	50	53	83	49	235
Morton	29	6	27	15	0	4	26	28	19	77	36	34	7	24	17	0	4	19	37	22	82
Mouswald	9	1	5	9	2	4	7	11	4	26	35	10	1	3	8	1	3	12	7	1	23
Penpont	13	4	37	10	0	9	27	23	5	64	36	14	6	34	10	1	7	21	31	6	65
St Mungo ..	15	6	9	12	0	27	4	2	9	42	37	22	1	17	11	0	24	7	6	14	51
Sanquhar ...	65	10	118	71	0	7	94	89	74	264	36	62	13	92	62	4	5	91	87	50	233
Tinwald	22	4	13	19	0	4	20	24	10	58	37	16	5	14	29	1	10	25	17	13	65
Torthorwald . .	39	4	13	35	1	16	28	40	8	92	[illegible]	29	7	15	33	3	10	20	36	21	87
Tundergarth . ..	12	1	18	15	0	0	26	3	17	46	37	17	1	19	13	0	0	30	7	13	50
Tynron .	4	3	14	5	0	6	6	10	4	26	36	16	0	11	2	0	5	8	12	4	29
Wamphray	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—		
Westerkirk	9	2	22	8	2	12	15	6	10	43	37	12	2	9	9	0	5	14	3	10	32
Totals	1503	262	2502	1336	43	745	1826	1941	1134	5646	—	1658	251	2085	1217	63	721	1702	1750	1101	5274

EDINBURGH.

Borthwick	34	2	16	11	2	18	16	21	10	65	47	31	8	19	7	1	21	23	12	10	66
Carrington	10	0	3	7	0	2	10	0	8	20	47	9	3	5	6	1	3	12	0	9	24
Cockpen	28	9	82	49	2	19	65	56	30	170	47	45	8	62	30	2	17	53	56	21	147
Colinton	84	21	184	78	3	75	124	106	65	370	46	85	18	147	75	3	60	79	116	73	328
Corstorphine	65	12	65	52	2	28	57	76	35	196	46	43	10	59	38	2	7	62	53	30	152
Cramond	32	10	64	44	4	18	54	47	35	154	46	47	8	60	18	2	14	65	26	30	135
Cranston	40	3	40	22	1	31	32	31	12	106	47	46	2	36	13	0	16	38	34	9	97
Crichton	14	1	57	21	1	19	31	31	13	94	47	23	0	41	20	3	22	28	19	18	87
Currie	45	11	83	42	1	15	53	72	42	182	46	51	9	72	36	0	20	45	57	46	168
Dalkeith (Town) ...	61	18	160	75	2	27	139	89	61	316	47	85	17	140	56	1	15	125	101	58	299
Edinburgh City ...	2584	529	4220	2388	98	1484	2927	2992	2416	9819	44	2593	485	4008	2518	139	1437	2908	2996	2402	9743
Fala and Soutra ...	8	1	22	3	0	0	15	18	1	34	47	14	2	11	8	0	0	13	17	5	35
Glencorse	28	5	57	17	0	27	35	22	23	107	47	45	6	49	32	0	32	36	23	41	132
Heriot	5	3	13	11	0	2	0	18	12	32	47	8	0	15	11	0	0	0	18	16	34
Inveresk (Landward)	35	8	28	20	0	16	29	26	20	91	46	32	10	23	13	0	14	24	25	15	78
Kirknewton & E. Calder	65	16	95	82	6	13	84	99	68	264	47	91	12	125	61	2	34	89	111	57	291
Lasswade	244	41	437	181	6	221	212	282	194	909	47	270	66	395	164	7	183	243	283	193	902
Leith Burgh	1365	343	2630	1411	42	611	1888	1978	1314	5791	45	1602	289	2443	1448	36	642	1913	2009	1254	5818
Liberton	117	23	168	82	8	74	93	120	111	398	46	110	22	150	61	1	66	89	102	87	344
Mid-Calder	25	2	18	27	0	5	33	17	17	72	47	24	3	25	17	0	5	23	23	18	69
Musselburgh	219	42	361	185	3	127	284	229	170	810	46	275	50	385	219	4	142	280	325	186	933
Newbattle	2	2	17	10	0	13	4	6	8	31	47	7	1	11	3	0	7	1	7	7	22
Penicuik ...	54	14	109	57	1	26	44	94	71	235	47	59	13	95	48	2	21	62	89	45	217
Ratho	46	10	71	28	1	25	49	57	25	156	46	41	11	44	33	2	25	50	32	24	131
Stobhill	116	28	144	60	3	78	103	104	66	351	47	101	19	158	57	4	81	85	101	72	339
Temple	20	3	19	17	0	29	5	7	18	59	47	23	4	12	8	0	23	5	12	7	47
West Calder	41	12	54	45	0	41	30	44	37	152	47	62	8	66	33	0	50	47	40	32	169
Totals	5387	1169	9217	5025	186	3044	6416	6642	4882	20984	—	5822	1084	8656	5033	212	2957	6398	6687	4765	20807

TABLE XV.—(*continued*). *County and Parish Data.*

ELGIN.

Parish	BOYS										District	GIRLS									
	Hair					Eyes				Totals		Hair					Eyes				Totals
	Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark			Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark	
Alves	11	3	49	15	0	4	20	45	9	78	*89*	13	2	63	9	1	7	19	54	8	88
Bellie	33	14	118	53	2	55	51	63	51	220	*88*	36	18	92	46	1	50	27	63	53	193
Birnie	7	2	1	27	1	5	5	24	4	38	*90*	23	3	4	19	3	6	13	25	8	52
Cromdale	14	9	42	19	1	24	26	17	18	85	*91*	22	7	23	25	1	18	24	21	15	78
Dallas	4	4	5	5	1	1	3	6	9	19	*90*	3	2	11	2	0	2	6	4	6	18
Drainie	90	15	158	79	2	70	100	84	90	344	*88*	74	15	114	75	6	52	80	88	64	284
Duffus	80	17	134	60	5	52	65	112	67	296	*89*	74	4	108	57	2	28	69	91	57	245
Dyke	21	6	40	14	1	2	24	38	18	82	*89*	24	4	34	22	0	2	29	35	18	84
Edinkillie	12	6	32	27	2	15	23	27	14	79	*90*	17	3	16	19	1	7	16	24	9	56
Elgin (Burgh)	234	23	146	116	3	168	107	120	127	522	*88*	220	24	161	144	8	144	110	159	144	557
Elgin (Landward) ...	63	8	50	58	7	50	50	56	30	186	*88*	72	8	61	41	8	53	35	58	44	190
Forres (Burgh) ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Kinloss	41	10	34	23	0	16	36	37	19	108	*89*	33	8	29	28	0	9	25	24	40	98
Knockando	13	5	65	27	0	34	25	33	18	110	*90*	34	9	72	46	0	34	51	56	20	161
New Spynie	8	6	17	6	1	2	11	12	13	38	*88*	6	1	10	3	0	1	8	8	3	20
Rafford	4	2	10	8	1	5	7	5	8	25	*90*	10	3	9	3	0	6	16	1	2	25
Rothes	75	12	78	47	5	44	61	71	41	217	*90*	74	10	82	40	7	50	49	64	50	213
St Andrews Lhanbryde	42	6	16	34	2	1	36	30	33	100	*88*	39	3	26	19	3	1	33	28	28	90
Speymouth	44	10	56	23	1	19	56	43	16	134	*88*	41	7	57	23	0	20	66	29	13	128
Urquhart	23	2	17	9	0	6	16	13	16	51	*88*	21	3	19	13	0	15	15	9	17	56
Totals	819	160	1068	650	35	573	722	836	601	2732	—	836	134	991	634	41	505	691	841	599	2636

FIFE.

Parish	BOYS										District	GIRLS									
	Hair					Eyes				Totals		Hair					Eyes				Totals
	Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark			Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark	
Abdie	0	0	18	4	0	0	10	1	11	22	*55*	0	1	19	2	0	0	17	1	4	22
Aberdour	55	11	59	18	3	18	55	40	33	146	*53*	46	10	54	31	1	20	46	44	32	142
Anstruther (Easter) ...	15	10	57	42	9	18	40	40	35	133	*54*	13	7	57	53	2	16	41	31	44	132
Anstruther (Wester) ...	8	2	14	4	0	3	9	13	3	28	*55*	9	2	8	7	0	8	5	3	10	26
Auchterderran ...	124	29	230	102	0	44	176	201	64	485	*53*	144	20	195	94	2	36	144	206	69	455
Auchtermuchty ...	4	0	7	0	2	3	1	6	3	13	*57*	10	1	4	0	3	3	4	9	2	18
Auchtertool	9	5	28	20	0	2	20	29	11	62	*53*	17	6	21	22	0	0	26	26	14	66
Ballingry	44	8	78	66	3	6	64	66	63	199	*57*	30	10	66	54	0	9	44	53	54	160
Balmerino	12	1	30	10	0	14	11	16	12	53	*55*	11	4	10	10	0	6	13	6	10	35
Beath	495	109	895	481	25	324	526	725	430	2005	*57*	480	82	686	518	7	309	439	629	396	1773
Burntisland (Burgh & Landward)	42	1	42	26	0	9	52	19	31	111	*53*	53	14	45	33	2	16	73	30	28	147

Cameron	19	5	35	15	0	16	15	27	16	74	*55*	30	1	23	22	0	19	18	22	17	76
Carnbee	15	3	36	14	6	11	22	17	24	74	*55*	15	3	21	13	2	10	12	15	17	54
Carnock	8	1	17	9	2	6	12	10	9	37	*52*	10	0	15	3	0	2	15	7	4	28
Collessie	44	13	99	46	1	19	35	112	37	203	*57*	35	5	66	38	1	19	31	70	25	145
Crail	25	3	83	28	0	1	40	72	26	139	*55*	26	3	64	19	0	2	33	53	24	112
Culross	18	5	23	17	0	1	30	11	21	63	*52*	37	3	9	16	0	2	30	15	18	65
Cults	14	4	15	36	3	9	24	24	15	72	*55*	11	0	21	28	2	6	18	22	16	62
Cupar (Landward) ...	4	2	1	1	0	0	3	2	3	8	*55*	5	2	4	2	0	0	6	3	4	13
Dairsie	29	3	12	11	4	11	9	20	19	59	*55*	20	5	10	13	3	5	15	12	19	51
Dalgety	13	1	13	14	0	11	10	11	9	41	*53*	15	1	20	5	0	18	2	4	17	41
Dunbog	9	1	15	4	0	0	4	18	7	29	*55*	10	4	12	8	1	0	7	17	11	35
Dunfermline (Burgh) ...	242	34	371	248	6	133	296	282	190	901	*52*	266	34	319	208	3	146	227	266	191	830
" (Landward)	238	29	232	182	11	117	200	189	186	692	*52*	288	18	242	150	8	151	200	168	187	706
Dunino	10	0	13	9	0	3	14	12	3	32	*55*	8	1	12	9	2	1	9	15	7	32
Dysart (Burgh) ...	69	15	119	51	8	60	58	84	60	262	*54*	92	15	117	51	8	54	83	88	58	283
Elie	23	5	23	17	0	0	31	26	11	68	*55*	20	3	21	10	0	0	25	20	9	54
Falkland	28	15	73	42	1	9	39	62	49	159	*57*	41	10	44	57	0	9	36	58	49	152
Flisk	9	2	9	11	0	1	17	9	4	31	*55*	8	0	9	13	0	0	12	10	8	30
Forgan	43	3	46	33	1	20	46	42	18	126	*55*	48	4	50	30	7	25	46	42	26	139
Inverkeithing	68	14	174	78	4	20	124	116	78	338	*53*	102	18	137	97	2	13	118	141	84	356
Kennoway	32	11	69	32	0	27	48	48	21	144	*54*	46	7	58	35	0	30	35	40	41	146
Kettle	6	0	3	3	0	0	5	2	5	12	*57*	9	1	2	3	0	0	10	2	3	15
Kilconquhar	18	9	41	39	0	10	35	36	26	107	*55*	19	6	21	22	0	5	30	18	15	68
Kilmany	0	1	11	1	0	2	3	3	5	13	*56*	2	1	5	1	0	2	4	0	3	9
Kilrenny	100	9	130	66	3	73	72	94	69	308	*55*	126	13	147	68	0	90	79	97	88	354
Kinghorn	60	18	70	43	2	29	39	73	52	193	*53*	70	6	59	29	2	40	30	52	44	166
Kinglassie	29	4	34	28	1	27	27	21	21	96	*54*	30	2	29	22	0	21	12	25	25	83
Kingsbarns	31	2	23	14	0	18	28	14	10	70	*55*	30	0	14	14	0	11	18	18	11	58
Kirkcaldy (Burgh) ...	207	43	412	280	19	141	243	355	222	961	*50*	254	41	372	223	8	90	255	314	239	898
" & Dysart (Land.)	23	5	27	57	1	1	56	32	24	113	*54*	28	8	34	30	1	6	54	28	13	101
Largo	60	10	54	22	3	25	40	62	22	149	*54*	74	7	41	29	1	21	33	64	34	152
Largoward	22	2	0	5	1	1	13	11	5	30	*55*	22	0	3	3	0	0	12	11	5	28
Leslie	42	24	241	48	0	11	99	178	67	355	*57*	80	10	211	88	0	17	68	211	93	389
Leuchars	51	11	109	55	2	7	83	77	61	228	*55*	83	9	71	51	2	10	79	79	48	216
Lochgelly	217	36	456	239	4	188	275	281	208	952	*53*	244	46	444	196	3	175	306	267	185	933
Markinch	103	24	256	92	6	93	112	153	123	481	*54*	113	18	213	95	1	81	116	143	100	440
Monimail	10	4	21	5	2	16	12	10	4	42	*56*	9	7	16	13	1	18	7	10	11	46
Moonzie	20	1	1	5	2	11	3	0	15	29	*56*	17	0	2	3	1	10	1	0	12	23
Newburgh	53	12	76	42	3	49	36	54	47	186	*55*	39	11	84	46	2	51	22	58	51	182
Newburn	9	1	1	0	1	4	6	1	1	12	*55*	72	3	1	5	3	8	1	7	3	19
Pittenweem	32	5	67	42	3	12	56	45	36	149	*55*	43	6	71	67	0	14	70	46	57	187
St Andrews (Burgh) ...	53	12	112	74	8	50	81	75	53	259	*55*	75	21	81	63	10	35	91	64	60	250
" (Landward)	5	2	9	13	0	0	14	4	11	29	*55*	8	0	4	15	0	0	13	7	7	27
St Monance	69	16	82	32	5	36	62	39	67	204	*55*	81	20	60	40	3	25	61	51	67	204
Scoonie	5	0	19	8	0	10	10	5	7	32	*54*	5	3	24	6	0	9	6	16	7	38
Springfield	22	10	28	13	0	5	26	31	11	73	*57*	25	2	27	12	2	2	32	21	13	68
Strathmiglo	53	8	57	30	1	33	41	45	30	149	*57*	54	7	45	46	2	33	44	39	38	154
Wemyss	17	4	64	19	0	0	23	61	20	104	*54*	25	5	55	9	0	0	33	39	22	94
Totals	3085	618	5340	2946	156	1768	3541	4112	2724	12145	—	3518	547	4575	2850	98	1709	3317	3813	2749	11588

TABLE XV.—(*continued*). *County and Parish Data.*

ELGIN.

Parish	BOYS										District	GIRLS									
	Hair					Eyes				Totals		Hair					Eyes				Totals
	Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark			Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark	
Alves	11	3	49	15	0	4	20	45	9	78	*89*	13	2	63	9	1	7	19	54	8	88
Bellie	33	14	118	53	2	55	51	63	51	220	*88*	36	18	92	46	1	50	27	63	53	193
Birnie	7	2	1	27	1	5	5	24	4	38	*90*	23	3	4	19	3	6	13	25	8	52
Cromdale	14	9	42	19	1	24	26	17	18	85	*91*	22	7	23	25	1	18	24	21	15	78
Dallas	4	4	5	5	1	1	3	6	9	19	*90*	3	2	11	2	0	2	6	4	6	18
Drainie	90	15	158	79	2	70	100	84	90	344	*88*	74	15	114	75	6	52	80	88	64	284
Duffus	80	17	134	60	5	52	65	112	67	296	*89*	74	4	108	57	2	28	69	91	57	245
Dyke	21	6	40	14	1	2	24	38	18	82	*89*	24	4	34	22	0	2	29	35	18	84
Edinkillie	12	6	32	27	2	15	23	27	14	79	*90*	17	3	16	19	1	7	16	24	9	56
Elgin (Burgh)	234	23	146	116	3	168	107	120	127	522	*88*	220	24	161	144	8	144	110	159	144	557
Elgin (Landward) ...	63	8	50	58	7	50	50	56	30	186	*88*	72	8	61	41	8	53	35	58	44	190
Forres (Burgh) ...	—	—	—	—			—			—	—	—	—	—	—	—	—	—	—	—	—
Kinloss	41	10	34	23	0	16	36	37	19	108	*89*	33	8	29	28	0	9	25	24	40	98
Knockando	13	5	65	27	0	34	25	33	18	110	*90*	34	9	72	46	0	34	51	56	20	161
New Spynie	8	6	17	6	1	2	11	12	13	38	*88*	6	1	10	3	0	1	8	8	3	20
Rafford	4	2	10	8	1	5	7	5	8	25	*90*	10	3	9	3	0	6	16	1	2	25
Rothes	75	12	78	47	5	44	61	71	41	217	*90*	74	10	82	40	7	50	49	64	50	213
St Andrews Lhanbryde	42	6	16	34	2	1	36	30	33	100	*88*	39	3	26	19	3	1	33	28	28	90
Speymouth	44	10	56	23	1	19	56	43	16	134	*88*	41	7	57	23	0	20	66	29	13	128
Urquhart	23	2	17	9	0	6	16	13	16	51	*88*	21	3	19	13	0	15	15	9	17	56
Totals	819	160	1068	650	35	573	722	836	601	2732	—	836	134	991	634	41	505	691	841	599	2636
FIFE.																					
Abdie	0	0	18	4	0	0	10	1	11	22	*55*	0	1	19	2	0	0	17	1	4	22
Aberdour	55	11	59	18	3	18	55	40	33	146	*53*	46	10	54	31	1	20	46	44	32	142
Anstruther (Easter) ...	15	10	57	42	9	18	40	40	35	133	*54*	13	7	57	53	2	16	41	31	44	132
Anstruther (Wester) ...	8	2	14	4	0	3	9	13	3	28	*55*	9	2	8	7	0	8	5	3	10	26
Auchterderran ...	124	29	230	102	0	44	176	201	64	485	*53*	144	20	195	94	2	36	144	206	69	455
Auchtermuchty ...	4	0	7	0	2	3	1	6	3	13	*57*	10	1	4	0	3	3	4	9	2	18
Auchtertool	9	5	28	20	0	2	20	29	11	62	*53*	17	6	21	22	0	0	26	26	14	66
Ballingry	44	8	78	66	3	6	64	66	63	199	*57*	30	10	66	54	0	9	44	53	54	160
Balmerino	12	1	30	10	0	14	11	16	12	53	*55*	11	4	10	10	0	6	13	6	10	35
Beath	495	109	895	481	25	324	526	725	430	2005	*57*	480	82	686	518	7	309	439	629	396	1773
Burntisland (Burgh & Landward)	42	1	42	26	0	9	52	19	31	111	*53*	53	14	45	33	2	16	73	30	28	147
Cameron	19	5	35	15	0	16	15	27	16	74	*55*	30	1	23	22	0	19	18	22	17	76
Carnbee	15	3	36	14	6	11	22	17	24	74	*55*	15	3	21	13	2	10	12	15	17	54
Carnock	8	1	17	9	2	6	12	10	9	37	*52*	10	0	15	3	0	2	15	7	4	28
Collessie	44	13	99	46	1	19	35	112	37	203	*57*	35	5	66	38	1	19	31	70	25	145
Crail	25	3	83	28	0	1	40	72	26	139	*55*	26	3	64	19	0	2	33	53	24	112
Culross	18	5	23	17	0	1	30	11	21	63	*52*	37	3	9	16	0	2	30	15	18	65
Cults	14	4	15	36	3	9	24	24	15	72	*55*	11	0	21	28	2	6	18	22	16	62
Cupar (Landward) ...	4	2	1	1	0	0	3	2	3	8	*55*	5	2	4	2	0	0	6	3	4	13
Dairsie	29	3	12	11	4	11	9	20	19	59	*55*	20	5	10	13	3	5	15	12	19	51
Dalgety	13	1	13	14	0	11	10	11	9	41	*53*	15	1	20	5	0	18	2	4	17	41
Dunbog	9	1	15	4	0	0	4	18	7	29	*55*	10	4	12	8	1	0	7	17	11	35
Dunfermline (Burgh) ...	242	34	371	248	6	133	296	282	190	901	*52*	266	34	319	208	3	146	227	266	191	830
„ (Landward)	238	29	232	182	11	117	200	189	186	692	*52*	288	18	242	150	8	151	200	168	187	706
Dunino	10	0	13	9	0	3	14	12	3	32	*55*	8	1	12	9	2	1	9	15	7	32
Dysart (Burgh) ...	69	15	119	51	8	60	58	84	60	262	*54*	92	15	117	51	8	54	83	88	58	283
Elie	23	5	23	17	0	0	31	26	11	68	*55*	20	3	21	10	0	0	25	20	9	54
Falkland	28	15	73	42	1	9	39	62	49	159	*57*	41	10	44	57	0	9	36	58	49	152
Flisk	9	2	9	11	0	1	17	9	4	31	*55*	8	0	9	13	0	0	12	10	8	30
Forgan	43	3	46	33	1	20	46	42	18	126	*55*	48	4	50	30	7	25	46	42	26	139
Inverkeithing	68	14	174	78	4	20	124	116	78	338	*53*	102	18	137	97	2	13	118	141	84	356
Kennoway	32	11	69	32	0	27	48	48	21	144	*54*	46	7	58	35	0	30	35	40	41	146
Kettle	6	0	3	3	0	0	5	2	5	12	*57*	9	1	2	3	0	0	10	2	3	15
Kilconquhar	18	9	41	39	0	10	35	36	26	107	*55*	19	6	21	22	0	5	30	18	15	68
Kilmany	0	1	11	1	0	2	3	3	5	13	*56*	2	1	5	1	0	2	4	0	3	9
Kilrenny	100	9	130	66	3	73	72	94	69	308	*55*	126	13	147	68	0	90	79	97	88	354
Kinghorn	60	18	70	43	2	29	39	73	52	193	*53*	70	6	59	29	2	40	30	52	44	166
Kinglassie	29	4	34	28	1	27	27	21	21	96	*54*	30	2	29	22	0	21	12	25	25	83
Kingsbarns	31	2	23	14	0	18	28	14	10	70	*55*	30	0	14	14	0	11	18	18	11	58
Kirkcaldy (Burgh) ...	207	43	412	280	19	141	243	355	222	961	*50*	254	41	372	223	8	90	255	314	239	898
„ & Dysart (Land.)	23	5	27	57	1	1	56	32	24	113	*54*	28	8	34	30	1	6	54	28	13	101
Largo	60	10	54	22	3	25	40	62	22	149	*54*	74	7	41	29	1	21	33	64	34	152
Largoward	22	2	0	5	1	1	13	11	5	30	*55*	22	0	3	3	0	0	12	11	5	28
Leslie	42	24	241	48	0	11	99	178	67	355	*57*	80	10	211	88	0	17	68	211	93	389
Leuchars	51	11	109	55	2	7	83	77	61	228	*55*	83	9	71	51	2	10	79	79	48	216
Lochgelly	217	36	456	239	4	188	275	281	208	952	*53*	244	46	444	196	3	175	306	267	185	933
Markinch	103	24	256	92	6	93	112	153	123	481	*54*	113	18	213	95	1	81	116	143	100	440
Monimail	10	4	21	5	2	16	12	10	4	42	*56*	9	7	16	13	1	18	7	10	11	46
Moonzie	20	1	1	5	2	11	3	0	15	29	*56*	17	0	2	3	1	10	1	0	12	23
Newburgh	53	12	76	42	3	49	36	54	47	186	*55*	39	11	84	46	2	51	22	58	51	182
Newburn	9	1	1	0	1	4	6	1	1	12	*55*	72	3	1	5	3	8	1	7	3	19
Pittenweem	32	5	67	42	3	12	56	45	36	149	*55*	43	6	71	67	0	14	70	46	57	187
St Andrews (Burgh) ...	53	12	112	74	8	50	81	75	53	259	*55*	75	21	81	63	10	35	91	64	60	250
„ (Landward)	5	2	9	13	0	0	14	4	11	29	*55*	8	0	4	15	0	0	13	7	7	27
St Monance	69	16	82	32	5	36	62	39	67	204	*55*	81	20	60	40	3	25	61	51	67	204
Scoonie	5	0	19	8	0	10	10	5	7	32	*54*	5	3	24	6	0	9	6	16	7	38
Springfield	22	10	28	13	0	5	26	31	11	73	*57*	25	2	27	12	2	2	32	21	13	68
Strathmiglo	53	8	57	30	1	33	41	45	30	149	*57*	54	7	45	46	2	33	44	39	38	154
Wemyss	17	4	64	19	0	0	23	61	20	104	*54*	25	5	55	9	0	0	33	39	22	94
Totals	3085	618	5340	2946	156	1768	3541	4112	2724	12145	—	3518	547	4575	2850	98	1709	3317	3813	2749	11588

TABLE XV.—(*continued*).

County and Parish Data.

FORFAR.

Parish	BOYS										District	GIRLS									
	HAIR					EYES				Totals		HAIR					EYES				Totals
	Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark			Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark	
Aberlemno	16	4	28	13	0	20	8	26	7	61	*73*	13	0	21	15	0	8	8	16	17	49
Airlie	13	2	17	2	0	7	0	21	6	34	*68*	19	3	23	1	0	11	0	23	12	46
Arbirlot	24	3	12	18	0	2	32	7	16	57	*65*	22	1	5	19	0	0	21	9	17	47
Auchterhouse	21	1	7	6	0	18	7	9	1	35	*68*	19	2	10	8	2	12	7	15	7	41
Arbroath (Burgh) ...	302	53	528	353	5	175	342	361	363	1241	*64*	280	63	505	372	14	138	360	370	366	1234
Barry	95	20	215	81	4	46	157	139	73	415	*65*	96	25	162	109	7	38	141	126	94	399
Brechin (Burgh) ...	83	23	245	103	1	63	143	150	99	455	*73*	74	29	213	84	2	62	125	127	88	402
,, (Landward) ...	30	6	27	21	0	25	27	14	18	84	*73*	35	2	22	19	0	19	31	13	15	78
Broughty Ferry (Burgh)	191	59	393	228	12	256	211	210	206	883	*65*	177	45	376	181	12	208	175	224	184	791
Careston	3	2	7	11	0	3	7	6	7	23	*73*	10	6	20	6	0	23	4	1	14	42
Carmyllie	47	5	47	23	1	22	39	34	28	123	*67*	45	8	31	20	1	32	31	30	12	105
Craig	30	10	30	8	2	19	18	25	18	80	*72*	35	4	34	11	0	25	12	30	17	84
Cortachy and Clovax ...	7	3	13	7	4	12	10	6	6	34	*75*	8	0	10	8	1	6	11	4	6	27
Dundee (Burgh) ...	2009	468	3925	2126	122	1258	2373	2929	2090	8650	*66*	2044	421	3540	2194	120	1168	2261	2855	2035	8319
,, (Landward) ...	29	8	39	26	0	12	36	21	33	102	*66*	40	3	20	35	0	10	34	25	29	98
Dunnichen	22	9	32	38	1	18	23	39	22	102	*67*	29	5	49	21	1	18	37	39	11	105
Eassie and Nevay ...	12	1	22	14	0	14	10	13	12	49	*68*	20	1	10	7	0	7	10	15	6	38
Edzell	34	5	47	16	1	24	27	26	26	103	*75*	28	7	13	19	0	16	13	20	18	67
Fern	9	1	7	11	0	0	16	12	0	28	*75*	9	0	8	11	0	0	10	16	2	28
Forfar (Burgh) ...	50	17	134	70	10	27	66	115	73	281	*67*	46	13	102	56	8	20	51	86	68	225
,, (Landward) ...	1	4	23	13	1	11	1	7	23	42	*67*	6	2	14	9	1	16	3	5	8	32
Fowlis Easter ...	8	0	2	13	1	0	4	11	9	24	*68*	13	3	2	14	0	1	12	11	8	32
Glamis	9	0	4	6	0	1	9	9	0	19	*67*	4	2	5	8	0	3	7	9	0	19
Glenisla	18	2	48	21	0	13	34	28	14	89	*76*	22	2	18	13	0	13	21	14	7	55
Guthrie	7	0	17	7	0	14	9	2	6	31	*73*	14	1	13	11	0	10	16	4	9	39
Inverarity	6	3	18	28	2	4	29	12	12	57	*67*	7	1	17	17	4	2	11	17	16	46
Inverkeilor	43	5	42	30	0	35	28	34	23	120	*65*	41	5	52	23	1	39	28	19	36	122
Kettins	9	3	30	10	0	18	2	20	12	52	*68*	7	2	18	16	0	16	4	11	12	43
Kinnell	14	2	18	26	0	8	21	16	15	60	*72*	13	2	19	8	0	7	10	5	20	42
Kinnettles	3	1	27	10	1	7	11	14	10	42	*67*	6	4	22	6	0	9	10	6	13	38
Kirkden	12	2	5	5	0	3	8	11	2	24	*67*	6	1	6	4	0	2	6	8	1	17
Kirriemuir	184	36	285	149	6	132	177	214	137	660	*75*	164	34	195	123	10	105	140	146	135	526
Liff, Benvie, etc. ...	34	11	52	25	0	20	46	33	23	122	*68*	34	7	51	26	0	18	49	32	19	118
Lintrathen	10	2	23	10	5	18	4	9	19	50	*76*	13	3	17	14	8	22	2	11	20	55
Lochlee	7	2	0	8	0	1	5	4	7	17	*75*	8	4	1	7	2	2	3	5	12	22
Logie Pert	8	3	29	5	0	1	21	16	7	45	*73*	20	5	18	3	0	2	23	13	8	46

Lunan	8	1	13	6	0	3	15	8	2	28	*72*	6	1	12	5	0	1	12	5	6	24
Lundie	11	2	7	8	0	2	2	12	12	28	*68*	14	3	4	7	0	4	0	17	7	28
Mains & Strathmartine	36	9	57	26	4	37	32	31	32	132	*68*	44	5	58	17	3	34	35	29	29	127
Maryton	8	1	12	12	0	2	10	7	14	33	*72*	4	2	12	5	0	2	8	3	10	23
Menmuir	13	1	22	14	0	10	18	8	14	50	*73*	16	0	14	15	0	2	19	10	14	45
Monifieth	34	9	102	54	4	14	43	102	44	203	*65*	34	13	85	40	1	10	47	79	37	173
Monikie	34	9	45	39	1	17	44	43	24	128	*67*	42	8	41	50	1	26	45	26	45	142
Montrose (Burgh) ...	173	30	252	126	3	107	162	183	132	584	*72*	156	14	211	92	7	68	158	144	110	480
,, (Landward)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Murroes	66	1	3	14	0	4	42	30	8	84	*67*	51	3	2	15	0	2	33	18	18	71
Navar and Lethnot ...	1	0	10	3	0	3	4	4	3	14	*75*	7	0	4	3	0	2	5	6	1	14
Newtyle	10	5	40	18	0	15	18	21	19	73	*68*	9	2	42	14	1	11	22	17	18	68
Oathlaw	8	1	23	9	0	17	2	16	6	41	*75*	14	2	10	9	0	15	1	13	6	35
Panbride	26	11	96	22	2	4	89	35	29	157	*65*	28	4	75	11	0	3	59	25	31	118
Rescobie	4	3	3	5	0	7	0	4	4	15	*73*	2	0	6	3	0	0	9	1	1	11
St Vigeans & Arbroath (Landward)	22	7	51	36	0	23	16	43	34	116	*65*	28	1	54	25	0	24	14	41	29	108
Tannadice	16	6	25	15	1	3	28	18	14	63	*75*	22	6	23	21	4	4	24	27	21	76
Tealing	17	6	14	18	0	19	7	9	20	55	*68*	18	5	18	10	0	19	10	13	9	51
Totals	3887	878	7173	3966	194	2594	4493	5177	3834	16098	—	3922	785	6313	3840	211	2315	4188	4834	3734	15071

HADDINGTON.

Aberlady	11	3	47	13	0	17	26	21	10	74	*43*	17	1	33	19	0	7	28	17	18	70
Bolton	5	3	8	4	0	1	7	8	4	20	*43*	3	2	8	0	0	2	4	4	3	13
Dirleton	11	7	13	13	0	7	7	17	13	44	*43*	7	0	17	8	0	5	1	18	8	32
Dunbar (Burgh) ...	64	14	145	48	7	47	84	83	64	278	*43*	72	12	122	51	6	34	91	82	56	263
,, (Landward) ...	10	2	10	9	2	0	13	13	7	33	*43*	23	1	11	10	0	1	18	18	8	45
Garvald	8	1	6	19	0	3	17	8	6	34	*43*	14	6	7	17	0	2	32	5	5	44
Gladsmuir	18	5	39	22	2	39	19	13	15	86	*43*	20	3	31	29	0	30	18	19	16	83
Haddington (Burgh) ...	74	14	143	71	1	63	70	120	50	303	*43*	97	22	162	81	1	66	96	134	67	363
Innerwick	7	5	24	12	0	19	7	11	11	48	*43*	29	2	10	18	0	23	17	11	8	59
Morham	7	3	7	7	0	2	11	8	3	24	*43*	8	2	8	11	0	4	10	6	9	29
North Berwick ...	82	16	108	55	3	47	95	69	53	264	*43*	91	16	86	57	1	44	102	50	55	251
Ormiston	28	11	81	17	2	25	42	45	27	139	*43*	27	9	70	16	0	31	41	32	18	122
Pencaitland	9	3	25	19	4	7	23	19	11	60	*43*	24	2	16	16	0	9	22	18	9	58
Prestonpans	71	13	149	82	3	73	65	96	84	318	*43*	96	15	101	75	1	65	68	82	73	288
Salton	15	4	21	8	1	9	12	19	9	49	*43*	16	2	20	13	2	6	9	24	14	53
Spott	8	6	13	5	0	7	14	5	6	32	*43*	1	5	7	2	0	1	4	6	4	15
Stenton	14	2	16	11	0	6	10	23	4	43	*43*	18	0	19	18	1	5	14	24	13	56
Whitekirk & Tyninghame	38	6	18	16	2	1	42	24	13	80	*43*	27	3	11	15	2	1	28	20	9	58
Whittinghame ...	8	0	9	9	0	0	12	9	5	26	*43*	11	1	13	4	0	4	18	3	4	29
Yester	9	5	30	26	4	7	13	30	24	74	*43*	24	4	18	36	4	13	16	22	35	86
Totals	497	123	912	466	31	380	589	641	419	2029	—	625	108	770	496	18	353	637	595	432	2017

TABLE XV.—*(continued)*.

County and Parish Data.

FORFAR.

Parish	BOYS												GIRLS									
	Hair					Eyes				Totals	District	Hair					Eyes				Totals
	Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark			Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark	
Aberlemno	16	4	28	13	0	20	8	26	7	61	73	13	0	21	15	0	8	8	16	17	49
Airlie	13	2	17	2	0	7	0	21	6	34	68	19	3	23	1	0	11	0	23	12	46
Arbirlot	24	3	12	18	0	2	32	7	16	57	65	22	1	5	19	0	0	21	9	17	47
Auchterhouse	21	1	7	6	0	18	7	9	1	35	68	19	2	10	8	2	12	7	15	7	41
Arbroath (Burgh)	302	53	528	353	5	175	342	361	363	1241	64	280	63	505	372	14	138	360	370	366	1234
Barry	95	20	215	81	4	46	157	139	73	415	65	96	25	162	109	7	38	141	126	94	399
Brechin (Burgh)	83	23	245	103	1	63	143	150	99	455	73	74	29	213	84	2	62	125	127	88	402
„ (Landward)	30	6	27	21	0	25	27	14	18	84	73	35	2	22	19	0	19	31	13	15	78
Broughty Ferry (Burgh)	191	59	393	228	12	256	211	210	206	883	65	177	45	376	181	12	208	175	224	184	791
Careston	3	2	7	11	0	3	7	6	7	23	73	10	6	20	6	0	23	4	1	14	42
Carmyllie	47	5	47	23	1	22	39	34	28	123	67	45	8	31	20	1	32	31	30	12	105
Craig	30	10	30	8	2	19	18	25	18	80	72	35	4	34	11	0	25	12	30	17	84
Cortachy and Clovax	7	3	13	7	4	12	10	6	6	34	75	8	0	10	8	1	6	11	4	6	27
Dundee (Burgh)	2009	468	3925	2126	122	1258	2373	2929	2090	8650	66	2044	421	3540	2194	120	1168	2261	2855	2035	8319
„ (Landward)	29	8	39	26	0	12	36	21	33	102	66	40	3	20	35	0	10	34	25	29	98
Dunnichen	22	9	32	38	1	18	23	39	22	102	67	29	5	49	21	1	18	37	39	11	105
Eassie and Nevay	12	1	22	14	0	14	10	13	12	49	68	20	1	10	7	0	7	10	15	6	38
Edzell	34	5	47	16	1	24	27	26	26	103	75	28	7	13	19	0	16	13	20	18	67
Fern	9	1	7	11	0	0	16	12	0	28	75	9	0	8	11	0	0	10	16	2	28
Forfar (Burgh)	50	17	134	70	10	27	66	115	73	281	67	46	13	102	56	8	20	51	86	68	225
„ (Landward)	1	4	23	13	1	11	1	7	23	42	67	6	2	14	9	1	16	3	5	8	32
Fowlis Easter	8	0	2	13	1	0	4	11	9	24	68	13	3	2	14	0	1	12	11	8	32
Glamis	9	0	4	6	0	1	9	9	0	19	67	4	2	5	8	0	3	7	9	0	19
Glenisla	18	2	48	21	0	13	34	28	14	89	76	22	2	18	13	0	13	21	14	7	55
Guthrie	7	0	17	7	0	14	9	2	6	31	73	14	1	13	11	0	10	16	4	9	39
Inverarity	6	3	18	28	2	4	29	12	12	57	67	7	1	17	17	4	2	11	17	16	46
Inverkeilor	43	5	42	30	0	35	28	34	23	120	65	41	5	52	23	1	39	28	19	36	122
Kettins	9	3	30	10	0	18	2	20	12	52	68	7	2	18	16	0	16	4	11	12	43
Kinnell	14	2	18	26	0	8	21	16	15	60	72	13	2	19	8	0	7	10	5	20	42
Kinnettles	3	1	27	10	1	7	11	14	10	42	67	6	4	22	6	0	9	10	6	13	38
Kirkden	12	2	5	5	0	3	8	11	2	24	67	6	1	6	4	0	2	6	8	1	17
Kirriemuir	184	36	285	149	6	132	177	214	137	660	75	164	34	195	123	10	105	140	146	135	526
Liff, Benvie, etc.	34	11	52	25	0	20	46	33	23	122	68	34	7	51	26	0	18	49	32	19	118
Lintrathen	10	2	23	10	5	18	4	9	19	50	76	13	3	17	14	8	22	2	11	20	55
Lochlee	7	2	0	8	0	1	5	4	7	17	75	8	4	1	7	2	2	3	5	12	22
Logie Pert	8	3	29	5	0	1	21	16	7	45	73	20	5	18	3	0	2	23	13	8	46
Lunan	8	1	13	6	0	3	15	8	2	28	72	6	1	12	5	0	1	12	5	6	24
Lundie	11	2	7	8	0	2	2	12	12	28	68	14	3	4	7	0	4	0	17	7	28
Mains & Strathmartine	36	9	57	26	4	37	32	31	32	132	68	44	5	58	17	3	34	35	29	29	127
Maryton	8	1	12	12	0	2	10	7	14	33	72	4	2	12	5	0	2	8	3	10	23
Menmuir	13	1	22	14	0	10	18	8	14	50	73	16	0	14	15	0	2	19	10	14	45
Monifieth	34	9	102	54	4	14	43	102	44	203	65	34	13	85	40	1	10	47	79	37	173
Monikie	34	9	45	39	1	17	44	43	24	128	67	42	8	41	50	1	26	45	26	45	142
Montrose (Burgh)	173	30	252	126	3	107	162	183	132	584	72	156	14	211	92	7	68	158	144	110	480
„ (Landward)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Murroes	66	1	3	14	0	4	42	30	8	84	67	51	3	2	15	0	2	33	18	18	71
Navar and Lethnot	1	0	10	3	0	3	4	4	3	14	75	7	0	4	3	0	2	5	6	1	14
Newtyle	10	5	40	18	0	15	18	21	19	73	68	9	2	42	14	1	11	22	17	18	68
Oathlaw	8	1	23	9	0	17	2	16	6	41	75	14	2	10	9	0	15	1	13	6	35
Panbride	26	11	96	22	2	4	89	35	29	157	65	28	4	75	11	0	3	59	25	31	118
Rescobie	4	3	3	5	0	7	0	4	4	15	73	2	0	6	3	0	0	9	1	1	11
St Vigeans & Arbroath (Landward)	22	7	51	36	0	23	16	43	34	116	65	28	1	54	25	0	24	14	41	29	108
Tannadice	16	6	25	15	1	3	28	18	14	63	75	22	6	23	21	4	4	24	27	21	76
Tealing	17	6	14	18	0	19	7	9	20	55	68	18	5	18	10	0	19	10	13	9	51
Totals	3887	878	7173	3966	194	2594	4493	5177	3834	16098	—	3922	785	6313	3840	211	2315	4188	4834	3734	15071

HADDINGTON.

Parish	BOYS												GIRLS									
	Hair					Eyes				Totals	District	Hair					Eyes				Totals
	Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark			Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark	
Aberlady	11	3	47	13	0	17	26	21	10	74	43	17	1	33	19	0	7	28	17	18	70
Bolton	5	3	8	4	0	1	7	8	4	20	43	3	2	8	0	0	2	4	4	3	13
Dirleton	11	7	13	13	0	7	7	17	13	44	43	7	0	17	8	0	5	1	18	8	32
Dunbar (Burgh)	64	14	145	48	7	47	84	83	64	278	43	72	12	122	51	6	34	91	82	56	263
„ (Landward)	10	2	10	9	2	0	13	13	7	33	43	23	1	11	10	0	1	18	18	8	45
Garvald	8	1	6	19	0	3	17	8	6	34	43	14	6	7	17	0	2	32	5	5	44
Gladsmuir	18	5	39	22	2	39	19	13	15	86	43	20	3	31	29	0	30	18	19	16	83
Haddington (Burgh)	74	14	143	71	1	63	70	120	50	303	43	97	22	162	81	1	66	96	134	67	363
Innerwick	7	5	24	12	0	19	7	11	11	48	43	29	2	10	18	0	23	17	11	8	59
Morham	7	3	7	7	0	2	11	8	3	24	43	8	2	8	11	0	4	10	6	9	29
North Berwick	82	16	108	55	3	47	95	69	53	264	43	91	16	86	57	1	44	102	50	55	251
Ormiston	28	11	81	17	2	25	42	45	27	139	43	27	9	70	16	0	31	41	32	18	122
Pencaitland	9	3	25	19	4	7	23	19	11	60	43	24	2	16	16	0	9	22	18	9	58
Prestonpans	71	13	149	82	3	73	65	96	84	318	43	96	15	101	75	1	65	68	82	73	288
Salton	15	4	21	8	1	9	12	19	9	49	43	16	2	20	13	2	6	9	24	14	53
Spott	8	6	13	5	0	7	14	5	6	32	43	1	5	7	2	0	1	4	6	4	15
Stenton	14	2	16	11	0	6	10	23	4	43	43	18	0	19	18	1	5	14	24	13	56
Whitekirk & Tyninghame	38	6	18	16	2	1	42	24	13	80	43	27	3	11	15	2	1	28	20	9	58
Whittinghame	8	0	9	9	0	0	12	9	5	26	43	11	1	13	4	0	4	18	3	4	29
Yester	9	5	30	26	4	7	13	30	24	74	43	24	4	18	36	4	13	16	22	35	86
Totals	497	123	912	466	31	380	589	641	419	2029	—	625	108	770	496	18	353	637	595	432	2017

TABLE XV.—(*continued*). *County and Parish Data.*

INVERNESS.

Parish	BOYS Hair Fair	Red	Medium	Dark	Jet Black	Eyes Blue	Light	Medium	Dark	Totals	District	GIRLS Hair Fair	Red	Medium	Dark	Jet Black	Eyes Blue	Light	Medium	Dark	Totals
Abernethy and Kincardine	51	7	26	24	4	31	18	38	25	112	*91*	47	5	27	30	3	17	23	41	31	112
Alvie	11	4	15	13	1	7	12	13	12	44	*91*	18	2	10	19	2	10	13	13	15	51
Arisaig and Moidart ...	15	2	16	7	1	15	9	13	4	41	*100*	11	1	12	11	0	8	9	12	6	35
Barra	20	5	113	75	0	20	80	57	56	213	*107*	30	6	113	65	1	19	101	42	53	215
Boleskine & Abertarff	12	6	42	33	1	9	48	19	18	94	*94*	14	10	28	25	0	5	48	16	8	77
Bracadale	17	3	10	34	1	7	15	24	19	65	*99*	17	0	18	22	2	13	12	16	18	59
Croy and Dalcross ...	6	7	44	25	2	8	27	29	20	84	*89*	14	5	28	30	0	8	14	30	25	77
Daviot and Dunlichty	17	5	22	20	2	16	18	19	13	66	*91*	26	4	18	19	4	21	20	14	16	71
Dores	15	4	18	16	3	14	19	10	13	56	*94*	25	4	20	15	1	22	25	13	5	65
Duirinish	43	3	29	44	0	15	42	19	43	119	*99*	34	2	29	39	1	10	32	25	38	105
Duthil & Rothiemurchus	57	9	48	33	8	13	67	49	26	155	*91*	54	7	45	32	19	19	55	54	19	147
Glenelg	35	4	28	19	3	26	19	23	21	89	*99*	30	2	26	25	2	24	20	18	23	85
Glengarry	16	3	9	5	1	10	6	12	6	34	*100 & 94*	14	2	13	7	0	8	9	10	9	36
Harris	37	1	99	89	2	29	81	62	56	228	*108*	37	1	88	74	2	35	79	41	47	202
Insh	1	0	1	4	0	6	0	0	0	6	*91*	4	1	3	5	0	7	3	0	3	13
Inverness (Burgh) ...	311	80	555	358	25	192	350	510	277	1329	*92*	330	55	484	372	17	212	348	431	267	1258
„ (Landward)	35	10	56	35	3	43	30	34	32	139	*92*	20	10	61	39	0	42	37	17	34	130
Kilmallie	71	17	98	86	10	47	96	72	67	282	*100*	59	15	69	61	11	28	79	58	50	215
Kilmonivaig	6	0	17	14	1	5	1	17	15	38	*100*	13	1	8	19	8	6	10	8	25	49
Kilmorack	29	10	53	35	2	27	49	20	33	129	*93*	32	6	59	31	7	23	63	24	25	135
Kilmuir	29	1	2	3	0	2	18	2	13	35	*99*	23	0	0	3	1	2	12	0	13	27
Kiltarlity	20	1	19	18	4	29	6	19	8	62	*94*	19	3	15	24	5	23	18	15	10	66
Kingussie	57	12	56	29	0	47	36	37	34	154	*91*	59	13	68	37	2	47	35	53	44	179
Kirkhill	28	2	21	12	1	19	23	13	9	64	*93*	29	2	15	17	2	15	24	19	7	65
Laggan	14	0	9	18	0	10	12	8	11	41	*91*	7	2	7	5	1	10	2	6	4	22
Moy and Dalarossie ...	19	1	25	12	1	17	24	7	10	58	*91*	26	3	22	12	2	24	21	6	14	65
North Uist	47	10	44	51	6	48	37	34	39	158	*107*	39	13	35	23	8	39	31	20	28	118
Petty	29	8	40	22	1	10	34	43	13	100	*89*	25	8	28	11	1	16	27	19	11	73
Portree	53	11	96	74	4	67	76	47	48	238	*99*	72	6	84	88	6	82	70	47	57	256
Sleat	23	2	44	31	4	11	37	36	20	104	*99*	23	1	18	29	1	11	24	19	18	72
Small Isles	5	1	10	7	0	2	4	14	3	23	*100*	13	1	8	3	4	4	5	9	11	29
Snizort	21	3	13	19	0	19	17	11	9	56	*99*	22	1	13	15	1	19	14	10	9	52
South Uist	78	2	62	37	1	37	56	66	21	180	*107*	35	12	57	34	3	41	36	37	27	141
Stenscholl	17	3	49	19	0	6	31	31	20	88	*99*	6	1	35	21	0	3	16	23	21	63
Strath	18	13	44	43	1	19	40	28	32	119	*99*	24	4	38	30	1	17	28	26	26	97
Urquhart & Glenmoriston	30	7	56	25	0	55	36	18	9	118	*94*	32	16	28	38	1	46	24	24	21	115
Totals	1293	257	1889	1389	93	938	1474	1454	1055	4921	—	1283	215	1630	1330	119	936	1387	1216	1038	4577

KINCARDINE.

Arbuthnot	17	4	15	20	0	0	7	35	14	56	*74*	14	1	21	13	1	2	11	29	8	50
Banchory, Devenick ...	55	8	61	36	0	18	55	47	40	160	*74*	43	9	61	32	0	21	52	39	33	145
,, Ternan ...	52	20	112	73	0	61	72	67	57	257	*79*	60	11	58	54	3	36	55	51	44	186
Benholm	54	3	39	25	1	16	50	37	19	122	*72*	57	4	54	40	3	26	53	47	32	158
Bervie	48	14	113	71	0	21	112	49	64	246	*72*	81	14	111	51	5	54	96	32	80	262
Dunnottar	61	6	99	104	7	27	114	84	52	277	*74*	100	16	83	84	4	41	97	109	40	287
Durris	2	1	14	2	0	3	7	5	4	19	*79*	28	2	29	6	0	10	34	8	13	65
Fettercairn	23	3	41	36	3	12	32	40	22	106	*73*	27	3	43	27	1	19	52	17	13	101
Fetteresso & Rickarton	97	26	152	117	4	68	112	128	88	396	*74*	131	36	147	101	6	74	154	105	88	421
Fordoun	39	5	78	43	0	15	54	57	39	165	*75*	39	7	53	26	1	17	41	45	23	126
Garvock	9	0	6	8	0	0	10	7	6	23	*72*	4	0	8	4	0	0	8	4	4	16
Glenbervie	3	1	36	8	0	5	11	27	5	48	*75*	8	2	43	9	0	5	22	27	8	62
Kinneff & Catterline ...	17	7	25	30	2	11	26	27	17	81	*74*	31	2	24	13	2	8	17	33	14	72
Laurencekirk	65	17	95	29	6	22	83	63	44	212	*73*	65	13	72	35	7	22	65	60	45	192
Maryculter	19	11	38	11	1	21	22	19	18	80	*74*	28	6	21	8	0	24	5	21	13	63
Marykirk	19	3	17	23	0	14	12	26	10	62	*73*	23	3	8	18	1	16	12	16	9	53
Nigg	30	4	57	28	0	26	41	25	27	119	*74*	28	9	43	43	0	16	56	29	22	123
St Cyrus	20	7	26	65	2	2	35	62	21	120	*72*	18	7	33	66	1	3	29	70	23	125
Strachan	17	1	26	10	0	18	15	17	4	54	*79*	12	1	17	10	1	19	7	10	5	41
Totals	647	141	1050	739	26	360	870	822	551	2603	—	797	146	929	640	36	413	866	752	517	2548

KINROSS.

Cleish	13	0	6	8	0	4	8	7	8	27	*57*	10	2	13	10	0	5	4	9	17	35
Fossoway & Tulliebole	12	5	36	22	4	12	23	26	18	79	*57*	23	5	21	11	4	9	19	24	12	64
Kinross	46	12	109	47	1	22	64	86	43	215	*57*	70	6	92	50	1	21	84	76	38	219
Orwell	39	7	81	25	0	23	45	51	33	152	*57*	44	6	72	27	0	27	39	54	29	149
Portmoak	15	2	36	16	0	5	28	27	9	69	*57*	12	7	25	15	0	3	26	16	14	59
Totals	125	26	268	118	5	66	168	197	111	542	—	159	26	223	113	5	65	172	179	110	526

KIRKCUDBRIGHT.

Anworth	18	5	25	21	0	16	21	24	8	69	*34*	16	3	24	20	2	9	25	25	6	65
Balmaclellan	4	1	22	10	0	2	15	13	7	37	*34*	3	0	19	7	0	4	10	9	6	29
Balmaghie	19	4	20	20	0	1	28	21	13	63	*34*	15	2	23	17	0	2	26	18	11	57
Bargrennan	11	0	10	13	0	12	6	12	4	34	*34*	14	0	3	8	0	12	4	9	0	25
Borgue	19	9	54	32	0	36	22	31	25	114	*34*	26	3	36	20	2	21	25	27	14	87
Buittle	9	5	22	16	1	1	18	23	11	53	*34*	16	5	22	13	0	4	18	21	13	56

TABLE XV.—(*continued*). *County and Parish Data.*

INVERNESS.

Parish	BOYS Hair Fair	Red	Medium	Dark	Jet Black	Eyes Blue	Light	Medium	Dark	Totals	District	GIRLS Hair Fair	Red	Medium	Dark	Jet Black	Eyes Blue	Light	Medium	Dark	Totals
Abernethy and Kincardine	51	7	26	24	4	31	18	38	25	112	91	47	5	27	30	3	17	23	41	31	112
Alvie	11	4	15	13	1	7	12	13	12	44	91	18	2	10	19	2	10	13	13	15	51
Arisaig and Moidart	15	2	16	7	1	15	9	13	4	41	100	11	1	12	11	0	8	9	12	6	35
Barra	20	5	113	75	0	20	80	57	56	213	107	30	6	113	65	1	19	101	42	53	215
Boleskine & Abertarff	12	6	42	33	1	9	48	19	18	94	94	14	10	28	25	0	5	48	16	8	77
Bracadale	17	3	10	34	1	7	15	24	19	65	99	17	0	18	22	2	13	12	16	18	59
Croy and Dalcross	6	7	41	25	2	8	27	29	20	84	89	14	5	28	30	0	8	14	30	25	77
Daviot and Dunlichty	17	5	22	20	2	16	18	19	13	66	91	26	4	18	19	4	21	20	14	16	71
Dores	15	4	18	16	3	14	19	10	13	56	94	25	4	20	15	1	22	25	13	5	65
Duirinish	43	3	29	44	0	15	42	19	43	119	99	34	2	29	39	1	10	32	25	38	105
Duthil & Rothiemurchus	57	9	48	33	8	13	67	49	26	155	91	54	7	45	32	19	19	55	54	19	147
Glenelg	35	4	28	19	3	26	19	23	21	89	99	30	2	26	25	2	24	20	18	23	85
Glengarry	16	3	9	5	1	10	6	12	6	34	100 & 94	14	2	13	7	0	8	9	10	9	36
Harris	37	1	99	89	2	29	81	62	56	228	108	37	1	88	74	2	35	79	41	47	202
Insh	1	0	1	4	0	6	0	0	0	6	91	4	1	3	5	0	7	3	0	3	13
Inverness (Burgh)	311	80	555	358	25	192	350	510	277	1329	92	330	55	484	372	17	212	348	431	267	1258
,, (Landward)	35	10	56	35	3	43	30	34	32	139	92	20	10	61	39	0	42	37	17	34	130
Kilmallie	71	17	98	86	10	47	96	72	67	282	100	59	15	69	61	11	28	79	58	50	215
Kilmonivaig	6	0	17	14	1	5	1	17	15	38	100	13	1	8	19	8	6	10	8	25	49
Kilmorack	29	10	53	35	2	27	49	20	33	129	93	32	6	59	31	7	23	63	24	25	135
Kilmuir	29	1	2	3	0	2	18	2	13	35	99	23	0	0	3	1	2	12	0	13	27
Kiltarlity	20	1	19	18	4	29	6	19	8	62	94	19	3	15	24	5	23	18	15	10	66
Kingussie	57	12	56	29	0	47	36	37	34	154	91	59	13	68	37	2	47	35	53	44	179
Kirkhill	28	2	21	12	1	19	23	13	9	64	93	29	2	15	17	2	15	24	19	7	65
Laggan	14	0	9	18	0	10	12	8	11	41	91	7	2	7	5	1	10	2	6	4	22
Moy and Dalarossie	19	1	25	12	1	17	24	7	10	58	91	26	3	22	12	2	24	21	6	14	65
North Uist	47	10	44	51	6	48	37	34	39	158	107	39	13	35	23	8	39	31	20	28	118
Petty	29	8	40	22	1	10	34	43	13	100	89	25	8	28	11	1	16	27	19	11	73
Portree	53	11	96	74	4	67	76	47	48	238	99	72	6	84	88	6	82	70	47	57	256
Sleat	23	2	44	31	4	11	37	36	20	104	99	23	1	18	29	1	11	24	19	18	72
Small Isles	5	1	10	7	0	2	4	14	3	23	100	13	1	8	3	4	4	5	9	11	29
Snizort	21	3	13	19	0	19	17	11	9	56	99	22	1	13	15	1	19	14	10	9	52
South Uist	78	2	62	37	1	37	56	66	21	180	107	35	12	57	34	3	41	36	37	27	141
Stenscholl	17	3	49	19	0	6	31	31	20	88	99	6	1	35	21	0	3	16	23	21	63
Strath	18	13	44	43	1	19	40	28	32	119	99	24	4	38	30	1	17	28	26	26	97
Urquhart & Glenmoriston	30	7	56	25	0	55	36	18	9	118	94	32	16	28	38	1	46	24	24	21	115
Totals	1293	257	1889	1389	93	938	1474	1454	1055	4921	—	1283	215	1630	1330	119	936	1387	1216	1038	4577

KINCARDINE

Parish	BOYS Hair Fair	Red	Medium	Dark	Jet Black	Eyes Blue	Light	Medium	Dark	Totals	District	GIRLS Hair Fair	Red	Medium	Dark	Jet Black	Eyes Blue	Light	Medium	Dark	Totals
Arbuthnot	17	4	15	20	0	0	7	35	14	56	74	14	1	21	13	1	2	11	29	8	50
Banchory, Devenick	55	8	61	36	0	18	55	47	40	160	74	43	9	61	32	0	21	52	39	33	145
,, Ternan	52	20	112	73	0	61	72	67	57	257	79	60	11	58	54	3	36	55	51	44	186
Benholm	54	3	39	25	1	16	50	37	19	122	72	57	4	54	40	3	26	53	47	32	158
Bervie	48	14	113	71	0	21	112	49	64	246	72	81	14	111	51	5	54	96	32	80	262
Dunnottar	61	6	99	104	7	27	114	84	52	277	74	100	16	83	84	4	41	97	109	40	287
Durris	2	1	14	2	0	3	7	5	4	19	79	28	2	29	6	0	10	34	8	13	65
Fettercairn	23	3	41	36	3	12	32	40	22	106	73	27	3	43	27	1	19	52	17	13	101
Fetteresso & Rickarton	97	26	152	117	4	68	112	128	88	396	74	131	36	147	101	6	74	154	105	88	421
Fordoun	39	5	78	43	0	15	54	57	39	165	75	39	7	53	26	1	17	41	45	23	126
Garvock	9	0	6	8	0	0	10	7	6	23	72	4	0	8	4	0	0	8	4	4	16
Glenbervie	3	1	36	8	0	5	11	27	5	48	75	8	2	43	9	0	5	22	27	8	62
Kinneff & Catterline	17	7	25	30	2	11	26	27	17	81	74	31	2	24	13	2	8	17	33	14	72
Laurencekirk	65	17	95	29	6	22	83	63	44	212	73	65	13	72	35	7	22	65	60	45	192
Maryculter	19	11	38	11	1	21	22	19	18	80	74	28	6	21	8	0	24	5	21	13	63
Marykirk	19	3	17	23	0	14	12	26	10	62	73	23	3	8	18	1	16	12	16	9	53
Nigg	30	4	57	28	0	26	41	25	27	119	74	28	9	43	43	0	16	56	29	22	123
St Cyrus	20	7	26	65	2	2	35	62	21	120	72	18	7	33	66	1	3	29	70	23	125
Strachan	17	1	26	10	0	18	15	17	4	54	79	12	1	17	10	1	19	7	10	5	41
Totals	647	141	1050	739	26	360	870	822	551	2603	—	797	146	929	640	36	413	866	752	517	2548

KINROSS.

Parish	BOYS Hair Fair	Red	Medium	Dark	Jet Black	Eyes Blue	Light	Medium	Dark	Totals	District	GIRLS Hair Fair	Red	Medium	Dark	Jet Black	Eyes Blue	Light	Medium	Dark	Totals
Cleish	13	0	6	8	0	4	8	7	8	27	57	10	2	13	10	0	5	4	9	17	35
Fossoway & Tulliebole	12	5	36	22	4	12	23	26	18	79	57	23	5	21	11	4	9	19	24	12	64
Kinross	46	12	109	47	1	22	64	86	43	215	57	70	6	92	50	1	21	84	76	38	219
Orwell	39	7	81	25	0	23	45	51	33	152	57	44	6	72	27	0	27	39	54	29	149
Portmoak	15	2	36	16	0	5	28	27	9	69	57	12	7	25	15	0	3	26	16	14	59
Totals	125	26	268	118	5	66	168	197	111	542	—	159	26	223	113	5	65	172	179	110	526

KIRKCUDBRIGHT.

Parish	BOYS Hair Fair	Red	Medium	Dark	Jet Black	Eyes Blue	Light	Medium	Dark	Totals	District	GIRLS Hair Fair	Red	Medium	Dark	Jet Black	Eyes Blue	Light	Medium	Dark	Totals
Anworth	18	5	25	21	0	16	21	24	8	69	34	16	3	24	20	2	9	25	25	6	65
Balmaclellan	4	1	22	10	0	2	15	13	7	37	34	3	0	19	7	0	4	10	9	6	29
Balmaghie	19	4	20	20	0	1	28	21	13	63	34	15	2	23	17	0	2	26	18	11	57
Bargrennan	11	0	10	13	0	12	6	12	4	34	34	14	0	3	8	0	12	4	9	0	25
Borgue	19	9	54	32	0	36	22	31	25	114	34	26	3	36	20	2	21	25	27	14	87
Buittle	9	5	22	16	1	1	18	23	11	53	34	16	5	22	13	0	4	18	21	13	56

TABLE XV.—(*continued*).

County and Parish Data.

KIRKCUDBRIGHT.—(*continued*).

Parish	BOYS										District	GIRLS									
	Hair					Eyes				Totals		Hair					Eyes				Totals
	Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark			Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark	
Carsphairn	2	0	14	0	1	4	1	10	2	17	*36*	7	1	12	8	0	2	7	13	6	28
Colvend and Southwick	36	5	40	22	0	20	42	25	16	103	*34*	38	5	34	27	3	25	33	34	15	107
Corsock	2	2	5	10	1	3	4	8	5	20	*34*	3	1	9	6	0	3	2	8	6	19
Crossmichael	5	6	17	9	0	2	18	13	4	37	*34*	12	0	15	5	0	0	14	15	3	32
Dalry	3	0	56	13	0	2	36	23	11	72	*36*	12	2	47	12	0	2	36	18	17	73
Girthon	10	1	11	16	0	13	4	8	13	38	*34*	15	4	26	5	0	12	10	18	10	50
Irongray	4	1	7	1	0	4	6	2	1	13	*36*	3	1	5	4	0	2	2	4	5	13
Kells	21	6	27	32	0	18	25	19	24	86	*34*	22	4	27	23	2	14	26	13	25	78
Kelton	84	18	181	97	1	66	131	111	73	381	*34*	106	13	149	77	0	58	133	87	67	345
Kirkbean	17	5	32	27	0	4	28	28	21	81	*34*	10	5	20	23	0	1	29	12	16	58
Kirkcudbright ...	54	14	122	83	2	15	85	93	82	275	*34*	71	20	116	70	4	12	95	94	80	281
Kirkgunzeon	11	3	12	10	2	22	2	6	8	38	*34*	13	2	10	12	1	23	2	8	5	38
Kirkmabreck	22	18	83	37	1	15	48	66	32	161	*34*	31	5	51	40	0	11	49	50	17	127
Kirkpatrick Durham ...	9	0	21	18	0	0	18	21	9	48	*34*	11	5	28	15	0	1	21	28	9	59
Lochrutton	14	1	13	11	1	17	6	10	7	40	*36*	14	0	9	11	2	12	9	8	7	36
Minnigaff	2	3	22	49	0	11	19	21	25	76	*33*	4	1	18	26	0	10	9	10	20	49
New Abbey	34	10	37	29	0	33	19	18	40	110	*34*	28	7	27	23	3	29	25	9	25	88
Parton	9	1	10	8	1	7	6	10	6	29	*34*	8	3	9	4	0	3	7	13	1	24
Rerrick	31	4	67	28	2	39	46	25	22	132	*34*	23	4	43	30	1	23	35	24	19	101
Terregles	6	1	9	2	0	9	2	2	5	18	*36*	4	2	7	4	2	3	5	6	5	19
Tongland	12	1	17	13	1	6	16	12	10	44	*34*	8	1	14	4	0	2	9	11	5	27
Troqueer	80	16	100	78	6	35	79	105	61	280	*36*	99	13	90	60	2	24	95	88	57	264
Twynholm	21	4	21	20	0	13	20	22	11	66	*34*	17	4	21	15	0	13	17	19	8	57
Urr	143	32	186	140	10	58	185	141	127	511	*34*	134	15	149	133	12	53	162	116	112	443
Totals	712	176	1263	865	30	484	956	923	683	3046	—	783	131	1063	722	36	390	940	815	590	2735

LANARK.

Parish	Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark	Totals	District	Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark	Totals
Airdrie	619	109	921	490	20	217	779	716	447	2159	*9*	570	91	846	507	18	241	726	582	483	2032
Avondale	150	32	176	94	8	40	141	185	94	460	*1*	79	13	99	58	0	37	87	86	39	249
Biggar	50	4	97	35	0	6	65	77	38	186	*1*	55	14	56	54	1	3	65	63	49	180
Blantyre	261	61	425	226	16	145	310	356	178	989	*15*	226	41	351	204	8	126	242	271	191	830

Bothwell	536	103	855	557	24	258	611	781	425	2075	*7*	551	110	779	470	15	254	562	681	428	1925
Cadder	157	36	246	117	2	69	179	203	107	558	*12*	183	26	191	112	3	82	179	162	92	515
Calderhead	235	54	322	176	9	88	334	248	126	796	*8*	248	45	331	156	13	124	277	260	132	793
Cambuslang	99	41	347	128	2	23	226	243	125	617	*15*	100	41	342	119	3	19	231	236	119	605
Cambusnethan ...	391	66	668	442	22	240	508	478	363	1589	*4*	412	89	667	416	19	307	419	496	381	1603
Carluke	138	33	293	193	6	52	206	268	137	663	*3*	174	36	255	180	3	55	196	273	124	648
Carmichael	1	1	23	3	0	0	4	20	4	28	*1*	3	2	21	4	0	0	8	19	3	30
Carmunnock	25	3	8	10	0	0	19	21	6	46	*14*	31	2	7	17	0	0	22	23	12	57
Carnwath	123	23	126	88	3	60	102	121	80	363	*2*	122	18	120	73	1	62	113	91	68	334
Carstairs	62	11	70	33	1	53	42	32	50	177	*2*	54	5	77	30	1	48	40	36	43	167
Clarkston	146	18	142	149	9	76	133	151	104	464	*9*	72	11	110	100	5	47	83	95	73	298
Covington & Thankerton	7	0	10	7	0	0	4	14	6	24	*1*	4	1	16	4	0	0	7	9	9	25
Crawford	21	1	17	29	2	17	15	18	20	70	*1*	16	1	13	12	0	7	12	12	11	42
Crawfordjohn	8	2	4	22	0	11	4	8	13	36	*1*	14	1	7	10	0	7	4	10	11	32
Culter	3	1	21	8	2	1	7	20	7	35	*1*	7	0	15	8	0	1	9	19	1	30
Dalziel	931	214	1547	904	50	369	1171	1294	812	3646	*6*	978	165	1384	794	30	366	1129	1126	730	3351
Dolphinton	6	2	10	8	0	7	4	8	7	26	*2*	10	1	10	9	0	4	4	11	11	30
Douglas	46	11	65	59	12	27	52	70	44	193	*1*	74	10	58	56	6	42	42	77	43	204
" Water ...	38	22	60	44	0	5	84	39	36	164	*1*	36	11	43	55	0	4	71	32	38	145
Dunsyre	5	1	13	1	0	1	6	10	3	20	*2*	6	3	10	0	0	1	5	9	4	19
East Kilbride	40	16	152	47	4	14	69	111	65	259	*3*	48	20	81	44	2	19	54	76	46	195
Glassford	33	7	36	47	0	11	37	44	31	123	*3*	49	5	33	30	3	11	47	46	16	120
Glasgow (Burgh) ...	6609	1597	13520	7798	346	3313	9131	10151	7275	29870	*13*	6125	1387	12447	8244	370	3423	8503	9651	6996	28573
Govan	1986	490	4355	2290	116	1351	2788	2920	2178	9237	*13*	1921	454	4065	2346	99	1253	2752	2747	2133	8885
Hamilton (Burgh) ...	457	79	716	407	31	249	504	575	362	1690	*5*	473	83	624	371	22	239	452	525	357	1573
" (Landward)	506	95	678	476	22	195	580	603	399	1777	*5*	530	94	605	448	15	192	577	531	392	1692
Lanark (Burgh) ...	121	40	228	100	1	125	74	157	134	490	*2*	130	35	207	80	2	92	101	119	142	454
" (Landward) ...	130	32	100	72	16	112	73	68	97	350	*2*	127	20	95	77	12	71	122	49	89	331
Larkhall	269	70	584	208	15	228	306	381	231	1146	*3*	308	49	535	231	11	232	324	365	213	1134
Lesmahagow	253	45	361	185	12	174	209	237	236	856	*1*	246	44	336	180	7	168	199	254	192	813
Libberton	13	0	1	1	1	16	0	0	0	16	*2*	5	1	0	6	0	7	0	3	2	12
Maryhill	566	140	1124	570	19	300	760	816	543	2419	*13*	602	111	1017	561	15	301	727	736	542	2306
New Monkland ...	119	18	236	73	2	75	123	169	81	448	*10*	199	25	219	90	3	95	168	161	112	536
Old Monkland ...	572	131	1338	687	31	354	780	1038	587	2759	*11*	666	152	1164	685	22	334	758	958	639	2689
Pettinain	4	2	9	5	0	4	4	5	7	20	*2*	5	0	6	5	0	4	2	7	3	16
Rutherglen	325	68	557	414	15	213	420	390	356	1379	*14*	337	51	535	403	2	224	385	378	341	1328
Shettleston	265	59	488	249	13	120	354	359	241	1074	*11*	231	44	351	214	15	85	257	324	189	855
Shotts	25	6	43	29	4	21	27	30	29	107	*8*	45	6	44	40	0	52	16	35	32	135
Springburn	36	34	234	177	1	6	132	208	136	482	*12*	34	27	152	179	2	15	111	154	114	394
Stonehouse	53	10	88	60	0	40	42	77	52	211	*3*	49	8	110	37	1	31	54	71	49	205
Wandell & Lamington	10	0	7	6	0	0	4	16	3	23	*1*	10	0	10	3	0	0	7	14	2	23
Wiston and Roberton	5	0	8	12	0	0	5	15	5	25	*1*	0	0	3	7	0	0	1	5	4	10
Totals	16455	3788	31329	17736	837	8686	21428	23751	16280	70145	—	16165	3353	28447	17729	729	8685	20150	21888	15700	66423

TABLE XV.—(*continued*).

County and Parish Data.

KIRKCUDBRIGHT.—(*continued*).

Parish	BOYS											GIRLS									
	HAIR					EYES				Totals	District	HAIR					EYES				Totals
	Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark			Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark	
Carsphairn	2	0	14	0	1	4	1	10	2	17	*36*	7	1	12	8	0	2	7	13	6	28
Colvend and Southwick	36	5	40	22	0	20	42	25	16	103	*34*	38	5	34	27	3	25	33	34	15	107
Corsock	2	2	5	10	1	3	4	8	5	20	*34*	3	1	9	6	0	3	2	8	6	19
Crossmichael	5	6	17	9	0	2	18	13	4	37	*34*	12	0	15	5	0	0	14	15	3	32
Dalry	3	0	56	13	0	2	36	23	11	72	*36*	12	2	47	12	0	2	36	18	17	73
Girthon	10	1	11	16	0	13	4	8	13	38	*34*	15	4	26	5	0	12	10	18	10	50
Irongray	4	1	7	1	0	4	6	2	1	13	*36*	3	1	5	4	0	2	2	4	5	13
Kells	21	6	27	32	0	18	25	19	24	86	*34*	22	4	27	23	2	14	26	13	25	78
Kelton	84	18	181	97	1	66	131	111	73	381	*34*	106	13	149	77	0	58	133	87	67	345
Kirkbean	17	5	32	27	0	4	28	28	21	81	*34*	10	5	20	23	0	1	29	12	16	58
Kirkcudbright ...	54	14	122	83	2	15	85	93	82	275	*34*	71	20	116	70	4	12	95	94	80	281
Kirkgunzeon	11	3	12	10	2	22	2	6	8	38	*34*	13	2	10	12	1	23	2	8	5	38
Kirkmabreck	22	18	83	37	1	15	48	66	32	161	*34*	31	5	51	40	0	11	49	50	17	127
Kirkpatrick Durham ...	9	0	21	18	0	0	18	21	9	48	*34*	11	5	28	15	0	1	21	28	9	59
Lochrutton	14	1	13	11	1	17	6	10	7	40	*36*	14	0	9	11	2	12	9	8	7	36
Minnigaff	2	3	22	49	0	11	19	21	25	76	*33*	4	1	18	26	0	10	9	10	20	49
New Abbey	34	10	37	29	0	33	19	18	40	110	*34*	28	7	27	23	3	29	25	9	25	88
Parton	9	1	10	8	1	7	6	10	6	29	*34*	8	3	9	4	0	3	7	13	1	24
Rerrick	31	4	67	28	2	39	46	25	22	132	*34*	23	4	43	30	1	23	35	24	19	101
Terregles	6	1	9	2	0	9	2	2	5	18	*36*	4	2	7	4	2	3	5	6	5	19
Tongland	12	1	17	13	1	6	16	12	10	44	*34*	8	1	14	4	0	2	9	11	5	27
Troqueer	80	16	100	78	6	35	79	105	61	280	*36*	99	13	90	60	2	24	95	88	57	264
Twynholm	21	4	21	20	0	13	20	22	11	66	*34*	17	4	21	15	0	13	17	19	8	57
Urr	143	32	186	140	10	58	185	141	127	511	*34*	134	15	149	133	12	53	162	116	112	443
Totals	712	176	1263	865	30	484	956	923	683	3046	—	783	131	1063	722	36	390	940	815	590	2735

LANARK.

Parish	BOYS											GIRLS									
	HAIR					EYES				Totals	District	HAIR					EYES				Totals
	Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark			Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark	
Airdrie	619	109	921	490	20	217	779	716	447	2159	*9*	570	91	846	507	18	241	726	582	483	2032
Avondale	150	32	176	94	8	40	141	185	94	460	*1*	79	13	99	58	0	37	87	86	39	249
Biggar	50	4	97	35	0	6	65	77	38	186	*1*	55	14	56	54	1	3	65	63	49	180
Blantyre	261	61	425	226	16	145	310	356	178	989	*15*	226	41	351	204	8	126	242	271	191	830
Bothwell	536	103	855	557	24	258	611	781	425	2075	*7*	551	110	779	470	15	254	562	681	428	1925
Cadder	157	36	246	117	2	69	179	203	107	558	*12*	183	26	191	112	3	82	179	162	92	515
Calderhead	235	54	322	176	9	88	334	248	126	796	*8*	248	45	331	156	13	124	277	260	132	793
Cambuslang	99	41	347	128	2	23	226	243	125	617	*15*	100	41	342	119	3	19	231	236	119	605
Cambusnethan .	391	66	668	442	22	240	508	478	363	1589	*4*	412	89	667	416	19	307	419	496	381	1603
Carluke	138	33	293	193	6	52	206	268	137	663	*3*	174	36	255	180	3	55	196	273	124	648
Carmichael	1	1	23	3	0	0	4	20	4	28	*1*	3	2	21	4	0	0	8	19	3	30
Carmunnock	25	3	8	10	0	0	19	21	6	46	*14*	31	2	7	17	0	0	22	23	12	57
Carnwath	123	23	126	88	3	60	102	121	80	363	*2*	122	18	120	73	1	62	113	91	68	334
Carstairs	62	11	70	33	1	53	42	32	50	177	*2*	54	5	77	30	1	48	40	36	43	167
Clarkston	146	18	142	149	9	76	133	151	104	464	*9*	72	11	110	100	5	47	83	95	73	298
Covington & Thankerton	7	0	10	7	0	0	4	14	6	24	*1*	4	1	16	4	0	0	7	9	9	25
Crawford	21	1	17	29	2	17	15	18	20	70	*1*	16	1	13	12	0	7	12	12	11	42
Crawfordjohn	8	2	4	22	0	11	4	8	13	36	*1*	14	1	7	10	0	7	4	10	11	32
Culter	3	1	21	8	2	1	7	20	7	35	*1*	7	0	15	8	0	1	9	19	1	30
Dalziel	931	214	1547	904	50	369	1171	1294	812	3646	*6*	978	165	1384	794	30	366	1129	1126	730	3351
Dolphinton	6	2	10	8	0	7	4	8	7	26	*2*	10	1	10	9	0	4	4	11	11	30
Douglas	46	11	65	59	12	27	52	70	44	193	*1*	74	10	58	56	6	42	42	77	43	204
„ Water ...	38	22	60	44	0	5	84	39	36	164	*1*	36	11	43	55	0	4	71	32	38	145
Dunsyre	5	1	13	1	0	1	6	10	3	20	*2*	6	3	10	0	0	1	5	9	4	19
East Kilbride	40	16	152	47	4	14	69	111	65	259	*3*	48	20	81	44	2	19	54	76	46	195
Glassford	33	7	36	47	0	11	37	44	31	123	*3*	49	5	33	30	3	11	47	46	16	120
Glasgow (Burgh) ...	6609	1597	13520	7798	346	3313	9131	10151	7275	29870	*15*	6125	1387	12447	8244	370	3423	8503	9651	6996	28573
Govan	1986	490	4355	2290	116	1351	2788	2920	2178	9237	*13*	1921	454	4065	2346	99	1253	2752	2747	2133	8885
Hamilton (Burgh) ...	457	79	716	407	31	249	504	575	362	1690	*5*	473	83	624	371	22	239	452	525	357	1573
„ Landward)	506	95	678	476	22	195	580	603	399	1777	*5*	530	94	605	448	15	192	577	531	392	1692
Lanark (Burgh) ..	121	40	228	100	1	125	74	157	134	490	*2*	130	35	207	80	2	92	101	119	142	454
„ (Landward) ...	130	32	100	72	16	112	73	68	97	350	*2*	127	20	95	77	12	71	122	49	89	331
Larkhall	269	70	584	208	15	228	306	381	231	1146	*3*	308	49	535	231	11	232	324	365	213	1134
Lesmahagow	253	45	361	185	12	174	209	237	236	856	*1*	246	44	336	180	7	168	199	254	192	813
Libberton	13	0	1	1	1	16	0	0	0	16	*2*	5	1	0	6	0	7	0	3	2	12
Maryhill	566	140	1124	570	19	300	760	816	543	2419	*13*	602	111	1017	561	15	301	727	736	542	2306
New Monkland ...	119	18	236	73	2	75	123	169	81	448	*10*	199	25	219	90	3	95	168	161	112	536
Old Monkland ...	572	131	1338	687	31	354	780	1038	587	2759	*11*	666	152	1164	685	22	334	758	958	639	2689
Pettinain	4	2	9	5	0	4	4	5	7	20	*2*	5	0	6	5	0	4	2	7	3	16
Rutherglen	325	68	557	414	15	213	420	390	356	1379	*14*	337	51	535	403	2	224	385	378	341	1328
Shettleston	265	59	488	249	13	120	354	359	241	1074	*11*	231	44	351	214	15	85	257	324	189	855
Shotts	25	6	43	29	4	21	27	30	29	107	*8*	45	6	44	40	0	52	16	35	32	135
Springburn	36	34	234	177	1	6	132	208	136	482	*12*	34	27	152	179	2	15	111	154	114	394
Stonehouse	53	10	88	60	0	40	42	77	52	211	*3*	49	8	110	37	1	31	54	71	49	205
Wandell & Lamington	10	0	7	6	0	0	4	16	3	23	*1*	10	0	10	3	0	0	7	14	2	23
Wiston and Roberton	5	0	8	12	0	0	5	15	5	25	*1*	0	0	3	7	0	0	1	5	4	10
Totals	16455	3788	31329	17736	837	8686	21428	23751	16280	70145		16165	3353	28447	17729	729	8685	20150	21888	15700	66423

TABLE XV.—(*continued*).

County and Parish Data.

LINLITHGOW.

Parish	BOYS										District	GIRLS									
	Hair					Eyes				Totals		Hair					Eyes				Totals
	Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark			Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark	
Abercorn	23	2	40	20	0	25	18	27	15	85	*48*	26	7	23	17	0	18	17	25	13	73
Bathgate (Burgh) ...	226	54	376	161	12	226	204	218	181	829	*49*	234	34	325	174	4	160	236	211	164	771
„ (Landward)	28	4	22	2	0	15	14	11	16	56	*49*	22	2	14	7	0	16	5	10	14	45
Bo'ness and Carriden	266	90	618	301	21	169	389	444	294	1296	*48*	330	86	526	317	15	209	359	395	311	1274
Dalmeny	46	6	40	24	1	2	52	47	16	117	*48*	52	4	39	18	0	0	59	32	22	113
Ecclesmachan	9	0	15	2	0	6	3	6	11	26	*48*	9	0	5	6	0	11	0	1	8	20
Kirkliston	93	19	147	91	10	72	101	102	85	360	*48*	115	9	112	100	2	77	84	102	75	338
Linlithgow	83	24	139	84	4	21	140	89	84	334	*48*	90	24	144	78	3	23	127	122	67	339
Livingstone	92	11	106	60	2	41	97	92	41	271	*48*	94	12	88	57	1	47	77	80	48	252
Torphichen	79	8	93	45	0	34	59	87	45	225	*49*	79	6	78	50	1	46	61	51	56	214
Uphall	210	67	472	194	4	59	340	396	152	947	*48*	227	44	407	192	3	55	282	373	163	873
Whitburn	144	26	210	110	4	48	208	145	93	494	*49*	181	24	155	87	9	59	191	108	98	456
Totals	1299	311	2278	1094	58	718	1625	1664	1033	5040	—	1459	252	1916	1103	38	721	1498	1510	1039	4768
NAIRN.																					
Ardclach	7	1	12	11	0	7	12	11	1	31	*90*	17	3	6	11	0	8	9	13	7	37
Auldearn	31	5	44	31	3	30	39	18	27	114	*89*	24	7	29	23	1	22	28	18	16	84
Cawdor	23	4	39	22	0	3	31	33	21	88	*89*	22	3	32	21	1	10	22	29	18	79
Nairn (Burgh) ...	55	7	92	16	1	19	36	90	26	171	*89*	55	10	90	41	1	36	39	88	34	197
„ (Landward) ...	20	8	45	17	0	17	53	14	6	90	*89*	35	7	27	17	0	20	39	25	2	86
Totals	136	25	232	97	4	76	171	166	81	494	—	153	30	184	113	3	96	137	173	77	483

ORKNEY.

Cross and Burness ...	24	3	19	18	0	19	13	24	8	64	*109*	24	2	19	14	0	22	12	22	3	59
Eday	8	0	10	11	0	0	13	11	5	29	*109*	14	0	6	4	0	0	14	8	2	24
Evie and Rendall ...	10	1	5	10	0	5	12	5	4	26	*109*	12	5	7	11	0	11	9	13	2	35
Firth and Stennis ...	36	4	44	29	6	16	35	47	21	119	*109*	22	7	28	33	5	7	24	40	24	95
Harray and Birsay ...	17	2	44	23	1	9	22	41	15	87	*109*	32	4	43	16	0	6	40	32	17	95
Holm	26	6	24	11	1	27	13	16	12	68	*109*	30	6	16	6	2	30	11	12	7	60
Hoy and Graemsay ...	16	4	23	6	1	19	14	10	7	50	*109*	12	1	10	8	0	13	9	3	6	31
Kirkwall (Burgh) ...	90	18	169	76	7	44	116	145	55	360	*109*	81	12	146	65	2	47	114	83	62	306
,, (Landward)	0	0	2	2	0	0	2	2	0	4	*109*	2	1	0	1	0	0	2	2	0	4
Lady	24	2	27	22	1	1	20	40	15	76	*109*	13	4	22	26	0	0	19	31	15	65
Orphir	38	1	25	19	0	10	33	30	10	83	*109*	49	5	13	16	0	10	37	29	7	83
Rousay and Egilshay ...	9	4	18	27	0	28	3	8	19	58	*109*	14	3	18	14	1	14	9	9	18	50
St Andrews & Deerness	25	2	23	27	1	16	15	35	12	78	*109*	32	2	27	9	0	17	18	27	8	70
Sandwick	13	3	13	18	0	2	7	19	19	47	*109*	9	3	8	13	0	4	3	13	13	33
Shapinsay	9	4	26	13	0	4	22	25	1	52	*109*	12	1	24	6	0	8	16	17	2	43
South Ronaldshay and Burray	33	21	115	44	3	39	85	57	35	216	*109*	61	11	81	41	4	47	69	57	25	198
Stromness	48	17	85	47	3	13	79	62	46	200	*109*	46	14	74	40	4	22	51	60	45	178
Stronsay	41	3	42	10	0	16	38	34	8	96	*109*	31	1	43	14	0	12	21	42	14	89
Walls and Flotta ...	42	4	41	19	3	24	31	34	20	109	*109*	30	3	28	30	3	15	26	35	18	94
Westray and Papa Westray	56	2	64	64	0	61	42	46	37	186	*109*	47	2	59	38	0	36	32	42	36	146
Totals	565	101	819	496	27	353	615	691	349	2008	—	573	87	672	405	21	321	536	577	324	1758

SHETLAND.

Bressay	8	2	34	6	0	5	18	15	12	50	*110*	14	4	20	10	0	3	27	10	8	48
Delting	26	5	37	20	2	45	24	10	11	90	*110*	23	3	23	20	7	28	30	7	11	76
Dunrossness	32	14	42	27	0	29	22	46	18	115	*110*	50	9	38	21	0	33	22	48	15	118
Fetlar	8	1	14	1	0	7	3	4	10	24	*110*	12	2	6	1	0	6	6	1	8	21
Lerwick	107	26	197	109	4	103	76	165	99	443	*110*	110	18	157	84	3	82	60	137	93	372
Nesting, Lunnasting, Whalsay & Skerries	36	5	29	24	6	23	33	17	27	100	*110*	44	2	30	16	3	22	20	25	28	95
Northmavine	33	6	35	22	1	22	34	18	23	97	*110*	20	6	23	9	0	11	21	8	18	58
Sandsting & Aithsting	31	5	26	41	0	26	34	23	20	103	*110*	11	5	13	30	0	17	21	14	7	59
Tingwall, Whiteness & Weisdale	21	13	53	35	3	36	27	35	27	125	*110*	34	6	37	18	1	24	17	24	31	96
Unst	29	10	27	33	2	31	22	21	27	101	*110*	25	5	22	19	2	29	16	12	16	73
Walls, Sandness, Papa and Foula	18	2	21	15	0	11	27	7	11	56	*110*	20	0	9	19	0	9	24	7	8	48
Yell	22	2	25	13	3	16	9	21	19	65	*110*	15	4	30	14	2	20	8	17	20	65
Totals	371	91	540	346	21	354	329	382	304	1369	—	378	64	408	261	18	284	272	310	263	1129

TABLE XV.—(*continued*).

County and Parish Data.

LINLITHGOW.

Parish	BOYS										District	GIRLS									
	Hair					Eyes				Totals		Hair					Eyes				Totals
	Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark			Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark	
Abercorn	23	2	40	20	0	25	18	27	15	85	*48*	26	7	23	17	0	18	17	25	13	73
Bathgate (Burgh) ...	226	54	376	161	12	226	204	218	181	829	*49*	234	34	325	174	4	160	236	211	164	771
„ (Landward)	28	4	22	2	0	15	14	11	16	56	*49*	22	2	14	7	0	16	5	10	14	45
Bo'ness and Carriden	266	90	618	301	21	169	389	444	294	1296	*48*	330	86	526	317	15	209	359	395	311	1274
Dalmeny	46	6	40	24	1	2	52	47	16	117	*48*	52	4	39	18	0	0	59	32	22	113
Ecclesmachan	9	0	15	2	0	6	3	6	11	26	*48*	9	0	5	6	0	11	0	1	8	20
Kirkliston	93	19	147	91	10	72	101	102	85	360	*48*	115	9	112	100	2	77	84	102	75	338
Linlithgow	83	24	139	84	4	21	140	89	84	334	*48*	90	24	144	78	3	23	127	122	67	339
Livingstone	92	11	106	60	2	41	97	92	41	271	*48*	94	12	88	57	1	47	77	80	48	252
Torphichen	79	8	93	45	0	34	59	87	45	225	*49*	79	6	78	50	1	46	61	51	56	214
Uphall	210	67	472	194	4	59	340	396	152	947	*48*	227	44	407	192	3	55	282	373	163	873
Whitburn	144	26	210	110	4	48	208	145	93	494	*49*	181	24	155	87	9	59	191	108	98	456
Totals	1299	311	2278	1094	58	718	1625	1664	1033	5040	—	1459	252	1916	1103	38	721	1498	1510	1039	4768

NAIRN.

Ardclach	7	1	12	11	0	7	12	11	1	31	*90*	17	3	6	11	0	8	9	13	7	37
Auldearn	31	5	44	31	3	30	39	18	27	114	*89*	24	7	29	23	1	22	28	18	16	84
Cawdor	23	4	39	22	0	3	31	33	21	88	*89*	22	3	32	21	1	10	22	29	18	79
Nairn (Burgh) ...	55	7	92	16	1	19	36	90	26	171	*89*	55	10	90	41	1	36	39	88	34	197
„ (Landward) ...	20	8	45	17	0	17	53	14	6	90	*89*	35	7	27	17	0	20	39	25	2	86
Totals	136	25	232	97	4	76	171	166	81	494	—	153	30	184	113	3	96	137	173	77	483

ORKNEY.

Cross and Burness ...	24	3	19	18	0	19	13	24	8	64	*109*	24	2	19	14	0	22	12	22	3	59
Eday	8	0	10	11	0	0	13	11	5	29	*109*	14	0	6	4	0	0	14	8	2	24
Evie and Rendall ...	10	1	5	10	0	5	12	5	4	26	*109*	12	5	7	11	0	11	9	13	2	35
Firth and Stennis ...	36	4	44	29	6	16	35	47	21	119	*109*	22	7	28	33	5	7	24	40	24	95
Harray and Birsay ...	17	2	44	23	1	9	22	41	15	87	*109*	32	4	43	16	0	6	40	32	17	95
Holm	26	6	24	11	1	27	13	16	12	68	*109*	30	6	16	6	2	30	11	12	7	60
Hoy and Graemsay ...	16	4	23	6	1	19	14	10	7	50	*109*	12	1	10	8	0	13	9	3	6	31
Kirkwall (Burgh) ...	90	18	169	76	7	44	116	145	55	360	*109*	81	12	146	65	2	47	114	83	62	306
„ (Landward)	0	0	2	2	0	0	2	2	0	4	*109*	2	1	0	1	0	0	2	2	0	4
Lady	24	2	27	22	1	1	20	40	15	76	*109*	13	4	22	26	0	0	19	31	15	65
Orphir	38	1	25	19	0	10	33	30	10	83	*109*	49	5	13	16	0	10	37	29	7	83
Rousay and Egilshay ...	9	4	18	27	0	28	3	8	19	58	*109*	14	3	18	14	1	14	9	9	18	50
St Andrews & Deerness	25	2	23	27	1	16	15	35	12	78	*109*	32	2	27	9	0	17	18	27	8	70
Sandwick	13	3	13	18	0	2	7	19	19	47	*109*	9	3	8	13	0	4	3	13	13	33
Shapinsay	9	4	26	13	0	4	22	25	1	52	*109*	12	1	24	6	0	8	16	17	2	43
South Ronaldshay and Burray	33	21	115	44	3	39	85	57	35	216	*109*	61	11	81	41	4	47	69	57	25	198
Stromness	48	17	85	47	3	13	79	62	46	200	*109*	46	14	74	40	4	22	51	60	45	178
Stronsay	41	3	42	10	0	16	38	34	8	96	*109*	31	1	43	14	0	12	21	42	14	89
Walls and Flotta ...	42	4	41	19	3	24	31	34	20	109	*109*	30	3	28	30	3	15	26	35	18	94
Westray and Papa Westray	56	2	64	64	0	61	42	46	37	186	*109*	47	2	59	38	0	36	32	42	36	146
Totals	565	101	819	496	27	353	615	691	349	2008	—	573	87	672	405	21	321	536	577	324	1758

SHETLAND.

Bressay	8	2	34	6	0	5	18	15	12	50	*110*	14	4	20	10	0	3	27	10	8	48
Delting	26	5	37	20	2	45	24	10	11	90	*110*	23	3	23	20	7	28	30	7	11	76
Dunrossness	32	14	42	27	0	29	22	46	18	115	*110*	50	9	38	21	0	33	22	48	15	118
Fetlar	8	1	14	1	0	7	3	4	10	24	*110*	12	2	6	1	0	6	6	1	8	21
Lerwick	107	26	197	109	4	103	76	165	99	443	*110*	110	18	157	84	3	82	60	137	93	372
Nesting, Lunnasting, Whalsay & Skerries	36	5	29	24	6	23	33	17	27	100	*110*	44	2	30	16	3	22	20	25	28	95
Northmavine	33	6	35	22	1	22	34	18	23	97	*110*	20	6	23	9	0	11	21	8	18	58
Sandsting & Aithsting	31	5	26	41	0	26	34	23	20	103	*110*	11	5	13	30	0	17	21	14	7	59
Tingwall, Whiteness & Weisdale	21	13	53	35	3	36	27	35	27	125	*110*	34	6	37	18	1	24	17	24	31	96
Unst	29	10	27	33	2	31	22	21	27	101	*110*	25	5	22	19	2	29	16	12	16	73
Walls, Sandness, Papa and Foula	18	2	21	15	0	11	27	7	11	56	*110*	20	0	9	19	0	9	24	7	8	48
Yell	22	2	25	13	3	16	9	21	19	65	*110*	15	4	30	14	2	20	8	17	20	65
Totals	371	91	540	346	21	354	329	382	304	1369	—	378	64	408	261	18	284	272	310	263	1129

TABLE XV.—(*continued*).

County and Parish Data.

PEEBLES.

Parish	BOYS										District	GIRLS									
	Hair					Eyes				Totals		Hair					Eyes				Totals
	Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark			Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark	
Drumelzier	2	3	4	1	0	0	1	5	4	10	*41*	2	2	12	1	0	0	4	8	5	17
Innerleithen	80	12	144	53	6	43	70	102	80	295	*41*	85	15	132	81	6	37	74	111	97	319
Kilbucho, Broughton and Glenholm	8	2	7	10	1	10	10	3	5	28	*41*	11	0	19	10	0	8	19	9	4	40
Newlands	12	2	22	19	2	7	23	18	9	57	*41*	12	1	25	13	0	11	13	21	6	51
Peebles	76	30	234	72	1	13	187	145	68	413	*41*	88	19	205	76	2	22	163	143	62	390
Stobo	0	2	12	5	1	10	7	3	0	20	*41*	4	0	12	6	0	12	2	6	2	22
Traquair	11	6	31	11	0	2	17	26	14	59	*41*	15	3	28	9	0	2	26	17	10	55
Tweedsmuir	5	1	14	11	0	5	7	6	13	31	*41*	7	2	11	6	0	7	5	8	6	26
West Linton	20	2	34	16	0	31	8	18	15	72	*41*	20	7	22	15	0	21	9	15	19	64
Totals	214	60	502	198	11	121	330	326	208	985	—	244	49	466	217	8	120	315	338	211	984

PERTH.

Parish	BOYS										District	GIRLS									
	Hair					Eyes				Totals		Hair					Eyes				Totals
	Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark			Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark	
Abernethy	24	4	44	11	0	15	19	33	16	83	*58*	23	6	21	14	1	9	22	22	12	65
Abernyte	11	6	10	17	0	1	16	21	6	44	*68*	8	1	16	12	0	3	15	13	6	37
Alyth	71	9	101	41	1	44	75	57	47	223	*70*	55	11	73	49	3	45	66	47	33	191
Amulree	7	1	5	11	1	3	18	2	2	25	*71*	6	0	8	6	1	1	8	9	3	21
Ardoch	9	1	19	10	0	2	26	8	3	39	*59*	9	2	10	9	0	1	17	12	0	30
Arngask	2	4	26	17	0	1	16	16	16	49	*58*	5	3	29	22	0	2	12	27	18	59
Auchterarder	66	9	83	70	3	25	83	75	48	231	*58*	58	10	114	78	5	28	73	98	66	265
Auchtergaven	46	7	60	51	5	25	60	44	40	169	*71*	54	11	67	50	4	21	80	41	44	186
Balquhidder	18	2	30	21	1	27	10	15	20	72	*59*	16	1	22	20	4	28	10	9	16	63
Blackford	32	10	39	37	2	7	57	34	22	120	*59*	36	7	44	33	1	12	52	28	29	121
Blair Atholl	31	6	45	41	1	11	35	50	28	124	*76*	37	5	34	25	0	9	33	42	17	101
Blairgowrie	141	16	88	83	17	72	38	123	112	345	*70*	129	19	55	83	10	71	31	91	103	296
Blairingone	12	4	6	12	1	12	3	10	10	35	*57*	16	3	14	13	0	14	9	13	10	46
Callander	46	3	22	35	10	18	37	30	31	116	*59*	25	4	34	32	11	10	31	37	28	106
Caputh	29	3	30	23	2	10	34	25	18	87	*71*	22	4	18	19	3	12	26	19	9	66
Cargill	39	9	41	26	0	35	22	35	23	115	*70*	47	6	27	30	0	30	25	33	22	110
Clunie	10	4	23	7	0	15	18	3	8	44	*70*	16	6	8	10	0	18	12	1	9	40
Collace	16	3	29	20	1	3	20	21	25	69	*70*	11	3	19	10	2	9	17	10	9	45
Comrie	26	12	76	41	2	30	55	40	32	157	*58*	41	8	52	60	2	34	56	51	22	163
Coupar Angus ...	79	7	90	56	5	46	62	69	60	237	*68*	80	14	81	63	3	24	61	87	69	241

Dron	6	1	4	3	0	0	4	8	2	14	*58*	8	2	2	3	0	1	6	7	1	15
Dull	33	8	84	88	10	29	68	55	71	223	*71*	60	8	72	81	2	43	52	69	59	223
Dunblane and Lecropt	56	16	127	58	4	49	67	90	55	261	*59*	63	11	115	67	2	42	87	85	44	258
Dunkeld and Dowally	28	7	51	26	2	19	26	40	29	114	*71*	32	5	44	24	1	15	26	41	24	106
Dunning	17	6	52	27	1	18	38	30	17	103	*58*	17	7	49	11	1	28	19	29	9	85
Errol	44	7	66	48	3	63	28	30	47	168	*68*	56	2	58	48	4	55	29	34	50	168
Findo-Gask	5	0	10	9	0	0	6	8	10	24	*58*	5	2	14	8	0	2	10	6	11	29
Forgandenny	15	0	8	2	0	5	14	6	0	25	*58*	11	3	14	1	0	3	19	7	0	29
Forteviot	5	3	27	14	0	1	13	31	4	49	*58*	16	2	18	13	0	0	19	21	9	49
Fortingall	9	4	15	10	1	7	17	7	8	39	*71*	9	4	14	3	0	13	11	1	5	30
Fowlis Wester ...	15	7	18	12	1	20	13	6	14	53	*71*	12	3	12	6	1	14	6	9	5	34
Gartmore	15	0	15	25	2	7	21	22	7	57	*59*	16	1	6	12	1	7	11	7	11	36
Glendevon	7	0	4	2	0	3	9	0	1	13	*57*	6	0	3	5	3	5	8	0	4	17
Inchture	11	5	24	13	0	7	8	17	21	53	*68*	10	5	20	17	0	13	7	17	15	52
Kenmore	35	0	35	23	3	22	27	23	24	96	*71*	32	4	25	24	0	14	31	21	19	85
Killin	35	1	38	16	3	13	51	21	8	93	*71*	23	3	31	32	0	16	41	18	14	89
Kilmadock	50	6	65	31	2	17	60	43	34	154	*59*	59	9	68	51	6	15	78	61	39	193
Kilspindie	14	8	15	2	3	5	24	1	12	42	*68*	16	2	21	0	2	1	25	0	15	41
Kincardine	13	4	56	32	1	16	34	38	18	106	*59*	22	6	55	22	0	15	48	27	15	105
Kinclaven	4	0	3	5	0	0	6	2	4	12	*70*	8	2	8	2	0	0	13	4	3	20
Kinfauns	13	2	17	11	1	6	9	21	8	44	*68*	13	1	13	4	0	7	2	16	6	31
Kinloch-Rannoch ...	3	1	11	3	3	9	1	7	4	21	*76*	8	0	7	2	2	7	0	6	6	19
Kinnaird	11	1	2	8	0	1	4	8	9	22	*68*	9	0	7	4	2	0	6	7	9	22
Kirkmichael	2	0	4	6	0	4	0	3	5	12	*76*	1	0	9	4	0	5	3	2	4	14
Lethendy and Kinloch	7	1	16	7	0	8	12	3	8	31	*70*	6	1	12	3	0	7	6	1	8	22
Little Dunkeld ...	22	2	24	12	0	11	28	15	6	60	*71*	11	0	33	7	1	3	29	14	6	52
Logie Almond ...	8	4	36	14	4	23	12	23	8	66	*71*	7	3	22	18	5	17	7	21	10	55
Logierait	33	3	22	12	0	10	27	21	12	70	*71*	31	2	12	9	1	10	21	18	6	55
Longforgan	18	1	24	13	0	11	18	18	9	56	*68*	16	7	19	13	0	6	9	20	20	55
Maderty	13	4	3	3	0	0	4	17	2	23	*58*	20	1	1	7	0	0	7	12	10	29
Meigle	29	4	39	20	6	26	29	27	16	98	*68*	27	5	29	15	5	23	20	17	21	81
Methven	28	6	37	25	2	6	42	31	19	98	*71*	23	4	43	40	2	9	50	27	26	112
Moulin	7	0	5	0	2	9	2	1	2	14	*76*	7	3	1	6	0	9	3	2	3	17
Muckart	11	3	14	4	2	2	21	6	5	34	*51*	9	3	12	1	0	4	10	10	1	25
Muthill	5	8	50	18	1	15	28	29	10	82	*58*	8	11	42	22	3	7	43	21	15	86
Persie	5	1	23	9	3	9	19	1	12	41	*70*	6	0	12	3	4	8	9	1	7	25
Perth (Burgh)	628	106	1019	558	18	275	697	793	564	2329	*69*	624	108	951	516	14	287	630	781	515	2213
„ E. Parish (Land.)	17	3	23	21	2	3	13	27	23	66	*69*	19	5	37	23	0	9	27	26	22	84
Port of Monteith ...	1	0	13	1	0	4	3	7	1	15	*59*	6	0	16	2	0	2	10	9	3	24
Redgorton	9	2	6	14	3	0	12	14	8	34	*70*	13	3	8	10	11	0	21	11	13	45
Rhynd	1	2	11	2	0	4	4	6	2	16	*58*	5	2	5	6	0	1	4	7	6	18
St Martin's	14	1	15	10	0	13	11	9	7	40	*70*	21	2	16	7	0	9	14	11	12	46
Scone	37	15	76	61	1	26	50	77	37	190	*70*	45	8	59	49	0	24	37	57	43	161
Tenandry	5	1	9	5	1	2	7	8	4	21	*76*	4	2	13	13	0	2	12	15	3	32
Tibbermore	5	1	7	18	0	6	13	4	8	31	*70*	3	1	9	12	0	6	5	8	6	25
Trinity Gask	4	1	2	10	1	9	0	1	8	18	*58*	7	0	5	8	0	10	0	1	9	20
Trossachs	9	4	15	8	0	23	4	2	7	36	*59*	7	0	7	7	3	12	1	0	11	24
Weem	1	0	15	5	0	1	12	4	4	21	*71*	3	1	10	2	0	2	9	3	2	16
Totals	2172	394	3286	2052	145	1283	2426	2506	1834	8049	—	2246	394	2944	1953	130	1230	2301	2385	1751	7667

TABLE XV.—(*continued*).

County and Parish Data.

PEEBLES.

Parish	BOYS Hair					BOYS Eyes				Totals	District	GIRLS Hair					GIRLS Eyes				Totals
	Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark			Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark	
Drumelzier	2	3	4	1	0	0	1	5	4	10	*41*	2	2	12	1	0	0	4	8	5	17
Innerleithen	80	12	141	53	6	43	70	102	80	295	*41*	85	15	132	81	6	37	74	111	97	319
Kilbucho, Broughton and Glenholm	8	2	7	10	1	10	10	3	5	28	*41*	11	0	19	10	0	8	19	9	4	40
Newlands	12	2	22	19	2	7	23	18	9	57	*41*	12	1	25	13	0	11	13	21	6	51
Peebles	76	30	234	72	1	13	187	145	68	413	*41*	88	19	205	76	2	22	163	143	62	390
Stobo	0	2	12	5	1	10	7	3	0	20	*41*	4	0	12	6	0	12	2	6	2	22
Traquair	11	6	31	11	0	2	17	26	14	59	*41*	15	3	28	9	0	2	26	17	10	55
Tweedsmuir	5	1	14	11	0	5	7	6	13	31	*41*	7	2	11	6	0	7	5	8	6	26
West Linton	20	2	34	16	0	31	8	18	15	72	*41*	20	7	22	15	0	21	9	15	19	64
Totals	214	60	502	198	11	121	330	326	208	985	—	244	49	466	217	8	120	315	338	211	984

PERTH.

Parish	BOYS Hair					BOYS Eyes				Totals	District	GIRLS Hair					GIRLS Eyes				Totals
	Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark			Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark	
Abernethy	24	4	44	11	0	15	19	33	16	83	*58*	23	6	21	14	1	9	22	22	12	65
Abernyte	11	6	10	17	0	1	16	21	6	44	*68*	8	1	16	12	0	3	15	13	6	37
Alyth	71	9	101	41	1	44	75	57	47	223	*70*	55	11	73	49	3	45	66	47	33	191
Amulree	7	1	5	11	1	3	18	2	2	25	*71*	6	0	8	6	1	1	8	9	3	21
Ardoch	9	1	19	10	0	2	26	8	3	39	*59*	9	2	10	9	0	1	17	12	0	30
Arngask	2	4	26	17	0	1	16	16	16	49	*58*	5	3	29	22	0	2	12	27	18	59
Auchterarder	66	9	83	70	3	25	83	75	48	231	*58*	58	10	114	78	5	28	73	98	66	265
Auchtergaven	46	7	60	51	5	25	60	44	40	169	*71*	54	11	67	50	4	21	80	41	44	186
Balquhidder	18	2	30	21	1	27	10	15	20	72	*59*	16	1	22	20	4	28	10	9	16	63
Blackford	32	10	39	37	2	7	57	34	22	120	*59*	36	7	44	33	1	12	52	28	29	121
Blair Atholl	31	6	45	41	1	11	35	50	28	124	*76*	37	5	34	25	0	9	33	42	17	101
Blairgowrie	141	16	88	83	17	72	38	123	112	345	*70*	129	19	55	83	10	71	31	91	103	296
Blairingone	12	4	6	12	1	12	3	10	10	35	*57*	16	3	14	13	0	14	9	13	10	46
Callander	46	3	22	35	10	18	37	30	31	116	*59*	25	4	34	32	11	10	31	37	28	106
Caputh	29	3	30	23	2	10	34	25	18	87	*71*	22	4	18	19	3	12	26	19	9	66
Cargill	39	9	41	26	0	35	22	35	23	115	*70*	47	6	27	30	0	30	25	33	22	110
Clunie	10	4	23	7	0	15	18	3	8	44	*70*	16	6	8	10	0	18	12	1	9	40
Collace	16	3	29	20	1	3	20	21	25	69	*70*	11	3	19	10	2	9	17	10	9	45
Comrie	26	12	76	41	2	30	55	40	32	157	*58*	41	8	52	60	2	34	56	51	22	163
Coupar Angus ...	79	7	90	56	5	46	62	69	60	237	*68*	80	14	81	63	3	24	61	87	69	241
Crieff	94	14	161	98	7	61	106	134	73	377	*58*	112	16	139	72	4	61	104	107	71	343
Drum	6	1	4	3	0	0	4	8	2	14	*58*	8	2	2	3	0	1	6	7	1	15
Dull	33	8	84	88	10	29	68	55	71	223	*71*	60	8	72	81	2	43	52	69	59	223
Dunblane and Lecropt	56	16	127	58	4	49	67	90	55	261	*59*	63	11	115	67	2	42	87	85	44	258
Dunkeld and Dowally	28	7	51	26	2	19	26	40	29	114	*71*	32	5	44	24	1	15	26	41	24	106
Dunning	17	6	52	27	1	18	38	30	17	103	*58*	17	7	49	11	1	28	19	29	9	85
Errol	44	7	66	48	3	63	28	30	47	168	*68*	56	2	58	48	4	55	29	34	50	168
Findo-Gask	5	0	10	9	0	0	6	8	10	24	*58*	5	2	14	8	0	2	10	6	11	29
Forgandenny	15	0	8	2	0	5	14	6	0	25	*58*	11	3	14	1	0	3	19	7	0	29
Forteviot	5	3	27	14	0	1	13	31	4	49	*58*	16	2	18	13	0	0	19	21	9	49
Fortingall	9	4	15	10	1	7	17	7	8	39	*71*	9	4	14	3	0	13	11	1	5	30
Fowlis Wester ...	15	7	18	12	1	20	13	6	14	53	*71*	12	3	12	6	1	14	6	9	5	34
Gartmore	15	0	15	25	2	7	21	22	7	57	*59*	16	1	6	12	1	7	11	7	11	36
Glendevon	7	0	4	2	0	3	9	0	1	13	*57*	6	0	3	5	3	5	8	0	4	17
Inchture	11	5	24	13	0	7	8	17	21	53	*68*	10	5	20	17	0	13	7	17	15	52
Kenmore	35	0	35	23	3	22	27	23	24	96	*71*	32	4	25	24	0	14	31	21	19	85
Killin	35	1	38	16	3	13	51	21	8	93	*71*	23	3	31	32	0	16	41	18	14	89
Kilmadock	50	6	65	31	2	17	60	43	34	154	*59*	59	9	68	51	6	15	78	61	39	193
Kilspindie	14	8	15	2	3	5	24	1	12	42	*68*	16	2	21	0	2	1	25	0	15	41
Kincardine	13	4	56	32	1	16	34	38	18	106	*59*	22	6	55	22	0	15	48	27	15	105
Kinclaven	4	0	3	5	0	0	6	2	4	12	*70*	8	2	8	2	0	0	13	4	3	20
Kinfauns	13	2	17	11	1	6	9	21	8	44	*68*	13	1	13	4	0	7	2	16	6	31
Kinloch-Rannoch ...	3	1	11	3	3	9	1	7	4	21	*76*	8	0	7	2	2	7	0	6	6	19
Kinnaird	11	1	2	8	0	1	4	8	9	22	*68*	9	0	7	4	2	0	6	7	9	22
Kirkmichael	2	0	4	6	0	4	0	3	5	12	*76*	1	0	9	4	0	5	3	2	4	14
Lethendy and Kinloch	7	1	16	7	0	8	12	3	8	31	*70*	6	1	12	3	0	7	6	1	8	22
Little Dunkeld ...	22	2	24	12	0	11	28	15	6	60	*71*	11	0	33	7	1	3	29	14	6	52
Logie Almond ...	8	4	36	14	4	23	12	23	8	66	*71*	7	3	22	18	5	17	7	21	10	55
Logierait	33	3	22	12	0	10	27	21	12	70	*71*	31	2	12	9	1	10	21	18	6	55
Longforgan	18	1	24	13	0	11	18	18	9	56	*68*	16	7	19	13	0	6	9	20	20	55
Maderty	13	4	3	3	0	0	4	17	2	23	*58*	20	1	1	7	0	0	7	12	10	29
Meigle	29	4	39	20	6	26	29	27	16	98	*68*	27	5	29	15	5	23	20	17	21	81
Methven	28	6	37	25	2	6	42	31	19	98	*71*	23	4	43	40	2	9	50	27	26	112
Moulin	7	0	5	0	2	9	2	1	2	14	*76*	7	3	1	6	0	9	3	2	3	17
Muckart	11	3	14	4	2	2	21	6	5	34	*51*	9	3	12	1	0	4	10	10	1	25
Muthill	5	8	50	18	1	15	28	29	10	82	*58*	8	11	42	22	3	7	43	21	15	86
Persie	5	1	23	9	3	9	19	1	12	41	*70*	6	0	12	3	4	8	9	1	7	25
Perth (Burgh)	628	106	1019	558	18	275	697	793	564	2329	*69*	624	108	951	516	14	287	630	781	515	2213
„ E. Parish (Land.)	17	3	23	21	2	3	13	27	23	66	*69*	19	5	37	23	0	9	27	26	22	84
Port of Monteith ...	1	0	13	1	0	4	3	7	1	15	*59*	6	0	16	2	0	2	10	9	3	24
Redgorton	9	2	6	14	3	0	12	14	8	34	*70*	13	3	8	10	11	0	21	11	13	45
Rhynd	1	2	11	2	0	4	4	6	2	16	*58*	5	2	5	6	0	1	4	7	6	18
St Martin's	14	1	15	10	0	13	11	9	7	40	*70*	21	2	16	7	0	9	14	11	12	46
Scone	37	15	76	61	1	26	50	77	37	190	*70*	45	8	59	49	0	24	37	57	43	161
Tenandry	5	1	9	5	1	2	7	8	4	21	*76*	4	2	13	13	0	2	12	15	3	32
Tibbermore	5	1	7	18	0	6	13	4	8	31	*70*	3	1	9	12	0	6	5	8	6	25
Trinity Gask	4	1	2	10	1	9	0	1	8	18	*58*	7	0	5	8	0	10	0	1	9	20
Trossachs	9	4	15	8	0	23	4	2	7	36	*59*	7	0	7	7	3	12	1	0	11	24
Weem	1	0	15	5	0	1	12	4	4	21	*71*	3	1	10	2	0	2	9	3	2	16
Totals	2172	394	3286	2052	145	1283	2426	2506	1834	8049	—	2246	394	2944	1953	130	1230	2301	2385	1751	7667

TABLE XV.—(*continued*).

County and Parish Data.

RENFREW.

Parish	BOYS										District	GIRLS									
	HAIR					EYES				Totals		HAIR					EYES				Totals
	Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark			Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark	
Cathcart	300	83	657	358	12	203	398	481	328	1410	*14*	333	61	624	335	21	197	442	437	298	1374
Eastwood	246	55	375	270	5	195	239	311	206	951	*16*	230	36	320	249	6	88	251	311	191	841
Erskine	35	1	39	28	3	42	23	20	21	106	*21*	30	4	31	26	4	37	21	13	24	95
Greenock (Burgh) ...	760	198	1749	946	47	546	1073	1205	876	3700	*24*	762	178	1569	984	32	504	1039	1177	805	3525
„ and Port Glasgow	68	7	76	45	0	29	88	52	27	196	*21*	45	16	89	34	3	40	64	43	40	187
Houston and Killallan	29	6	54	30	2	6	42	40	33	121	*17*	39	6	35	18	3	15	32	36	18	101
Inverkip	6	1	33	14	0	3	11	29	11	54	*23*	8	1	16	17	0	3	13	14	12	42
Kilbarchan	70	16	154	106	3	41	144	87	77	349	*17*	78	20	136	115	0	34	123	105	87	349
Kilmalcolm	49	14	103	43	0	10	75	82	42	209	*21*	49	5	65	41	0	24	47	63	26	160
Levern	29	7	75	37	1	1	33	91	24	149	*16*	30	1	50	35	5	0	30	66	25	121
Lochwinnoch	51	17	118	45	2	22	69	91	51	233	*17*	58	11	132	77	0	27	75	118	58	278
Mearns	85	17	119	67	1	46	90	89	64	289	*16*	101	14	98	73	1	39	100	85	63	287
Neilston	238	48	330	223	12	157	278	267	149	851	*17*	183	32	301	192	13	86	243	236	156	721
Paisley (Burgh) ...	626	128	1069	550	62	417	659	783	576	2435	*18*	575	121	977	605	56	435	636	705	558	2334
„ (Landward) ...	79	9	81	56	3	18	88	65	57	228	*20*	83	8	90	60	5	11	90	64	81	246
Port Glasgow (Burgh)	130	28	279	128	13	83	136	231	128	578	*21*	107	16	240	134	5	67	103	210	122	502
Renfrew (Landward) ...	159	45	327	181	10	61	236	275	150	722	*19*	153	44	322	192	15	51	223	262	190	726
Totals	2960	680	5638	3127	176	1880	3682	4199	2820	12581	—	2864	574	5095	3187	169	1658	3532	3945	2754	11889
ROSS AND CROMARTY.																					
Alness	1	3	6	2	0	3	8	1	0	12	*93*	2	2	4	0	0	0	3	5	0	8
Applecross	36	11	51	20	11	22	51	33	23	129	*99*	41	11	35	29	1	19	48	36	14	117
Avoch	47	7	43	35	0	47	16	42	27	132	*93*	57	3	64	22	0	47	23	39	37	146
Barvas	91	5	87	41	7	56	79	34	62	231	*108*	80	7	87	49	6	57	75	39	58	229
Carnoch	2	0	3	4	0	0	4	5	0	9	*93*	6	0	3	5	0	2	7	4	1	14
Contin	0	0	5	1	0	1	1	3	1	6	*93*	1	0	4	2	0	1	2	2	2	7
Cromarty	1	0	10	8	0	1	7	10	1	19	*93*	5	0	23	0	0	2	18	7	1	28
Dingwall	93	18	95	91	6	60	101	73	69	303	*93*	96	16	86	89	13	60	89	80	71	300
Fearn	31	5	35	51	2	2	50	50	22	124	*95*	31	4	44	47	2	1	46	48	33	128
Fodderty	32	5	62	37	0	26	49	41	20	136	*93*	34	7	60	30	1	24	34	54	20	132

Gairloch	56	11	100	90	8	51	103	73	38	265	*99*	63	12	90	60	9	42	89	58	45	234
Glenshiel	6	0	6	6	0	1	7	6	4	18	*99*	9	1	10	4	0	1	7	13	3	24
Killearnan	18	0	25	18	1	8	20	22	12	62	*93*	21	2	18	17	2	3	19	25	13	60
Kilmuir Easter ...	35	5	26	11	7	21	30	20	13	84	*95*	37	3	19	20	2	24	27	22	8	81
Kincardine	12	7	13	23	0	8	11	25	11	55	*96*	21	2	18	16	2	14	22	16	7	59
Kinloch Luichart ...	10	0	9	11	0	12	3	9	6	30	*93 & 99*	18	1	5	12	1	16	7	7	7	37
Knockbain	15	4	28	26	5	18	16	22	22	78	*93*	22	1	38	27	2	22	20	24	24	90
Lochalsh	28	9	38	31	4	30	11	44	25	110	*99*	29	2	17	34	1	20	9	32	22	83
Lochbroom	71	21	83	70	4	21	81	92	55	249	*99*	82	15	62	60	4	29	73	79	42	223
Lochcarron	3	2	11	14	0	1	9	14	6	30	*99*	5	3	16	16	2	10	15	7	10	42
Lochs	149	19	142	139	5	85	168	115	86	454	*108*	147	19	117	123	12	86	132	99	101	418
Logie Easter	3	4	16	15	6	25	9	7	3	44	*95*	10	0	9	9	4	20	2	6	4	32
Nigg	19	0	23	20	0	13	9	26	14	62	*93*	19	0	15	21	0	19	9	15	12	55
Resolis	20	2	28	11	0	16	24	20	1	61	*93*	25	0	32	30	6	29	25	34	5	93
Rosemarkie	44	8	62	40	2	27	49	49	31	156	*93*	52	6	53	35	0	26	60	34	26	146
Rosskeen	24	8	53	43	2	7	55	49	19	130	*95*	45	13	58	43	2	11	65	59	26	161
Stornoway	121	47	324	143	10	104	152	242	147	645	*108*	131	46	275	156	9	97	115	267	138	617
Tain	39	12	71	54	5	30	59	61	31	181	*95*	36	8	56	43	1	19	53	41	31	144
Tarbat	31	5	54	35	1	36	26	42	22	126	*95*	35	2	54	47	1	35	25	41	38	139
Uig	146	19	162	67	9	117	118	103	65	403	*108*	111	17	125	60	9	93	89	91	49	322
Urquhart and Logie Wester	38	10	65	50	2	17	55	47	46	165	*93*	47	8	53	45	0	18	46	46	43	153
Urray	53	9	41	34	0	37	47	41	12	137	*93*	45	10	45	28	0	32	49	39	8	128
Totals	1275	256	1777	1241	97	903	1428	1421	894	4646	—	1363	221	1595	1179	92	879	1303	1369	899	4450
ROXBURGH.																					
Ancrum	26	4	40	17	0	22	15	19	31	87	*39*	23	2	16	11	0	19	5	11	17	52
Bedrule	3	2	7	6	0	2	6	10	0	18	*39*	2	0	1	1	0	1	1	2	0	4
Bowden	5	6	16	14	1	3	19	9	11	42	*39*	10	4	18	13	2	7	19	7	14	47
Castleton	3	3	15	3	0	0	11	11	2	24	*37*	3	2	7	6	0	3	8	5	2	18
Cavers and Kirkton ...	28	2	43	20	0	7	37	25	24	93	*38*	28	4	30	14	1	3	29	26	19	77
Crailing	2	0	18	3	0	0	15	6	2	23	*39*	8	0	18	3	0	6	18	1	4	29
Eckford	9	1	10	2	0	10	1	11	0	22	*39*	12	0	10	0	0	9	0	11	2	22
Edgerston	2	0	6	5	2	0	3	8	4	15	*39*	3	2	13	8	1	0	2	20	5	27
Ednam	18	4	34	5	2	10	32	12	9	63	*39*	20	3	16	5	2	6	17	7	16	46
Hawick (Burgh) ...	254	50	336	175	11	122	266	270	168	826	*38*	244	41	324	169	8	122	241	231	192	786
„ (Landward) ...	25	6	25	22	1	11	43	7	18	79	*38*	26	6	14	19	2	5	32	14	16	67
Hobkirk	5	5	30	6	0	23	14	5	4	46	*39*	6	0	25	7	0	16	10	10	2	38
Jedburgh	113	30	110	86	4	73	93	69	108	343	*39*	84	21	101	69	2	47	86	64	80	277
„ (Landward)...	9	4	17	9	0	8	6	16	9	39	*39*	10	0	16	18	1	10	5	25	5	45
Kelso	43	3	73	44	0	33	42	49	39	163	*39*	43	15	51	52	1	42	43	34	43	162
Lilliesleaf	17	4	13	13	3	17	8	10	15	50	*39*	22	2	12	11	4	14	14	12	11	51
Linton	8	1	6	11	1	3	8	13	3	27	*39*	2	2	12	7	0	6	7	2	8	23
Makerstoun	9	0	16	5	0	3	7	8	12	30	*39*	8	1	10	9	2	2	9	8	11	30

TABLE XV.—(*continued*).

County and Parish Data.

RENFREW.

Parish	BOYS											GIRLS									
	Hair					Eyes				Totals	District	Hair					Eyes				Totals
	Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark			Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark	
Cathcart	300	83	657	358	12	203	398	481	328	1410	*14*	333	61	624	335	21	197	442	437	298	1374
Eastwood	246	55	375	270	5	195	239	311	206	951	*16*	230	36	320	249	6	88	251	311	191	841
Erskine	35	1	39	28	3	42	23	20	21	106	*21*	30	4	31	26	4	37	21	13	24	95
Greenock (Burgh) ...	760	198	1749	946	47	546	1073	1205	876	3700	*24*	762	178	1569	984	32	504	1039	1177	805	3525
„ and Port Glasgow	68	7	76	45	0	29	88	52	27	196	*21*	45	16	89	34	3	40	64	43	40	187
Houston and Killallan	29	6	54	30	2	6	42	40	33	121	*17*	39	6	35	18	3	15	32	36	18	101
Inverkip	6	1	33	14	0	3	11	29	11	54	*23*	8	1	16	17	0	3	13	14	12	42
Kilbarchan	70	16	154	106	3	41	144	87	77	349	*17*	78	20	136	115	0	34	123	105	87	349
Kilmalcolm	49	14	103	43	0	10	75	82	42	209	*21*	49	5	65	41	0	24	47	63	26	160
Levern	29	7	75	37	1	1	33	91	24	149	*16*	30	1	50	35	5	0	30	66	25	121
Lochwinnoch	51	17	118	45	2	22	69	91	51	233	*17*	58	11	132	77	0	27	75	118	58	278
Mearns	85	17	119	67	1	46	90	89	64	289	*16*	101	14	98	73	1	39	100	85	63	287
Neilston	238	48	330	223	12	157	278	267	149	851	*17*	183	32	301	192	13	86	243	236	156	721
Paisley (Burgh) ...	626	128	1069	550	62	417	659	783	576	2435	*18*	575	121	977	605	56	435	636	705	558	2334
„ (Landward) ...	79	9	81	56	3	18	88	65	57	228	*20*	83	8	90	60	5	11	90	64	81	246
Port Glasgow (Burgh)	130	28	279	128	13	83	136	231	128	578	*21*	107	16	240	134	5	67	103	210	122	502
Renfrew (Landward) ...	159	45	327	181	10	61	236	275	150	722	*19*	153	44	322	192	15	51	223	262	190	726
Totals	2960	680	5638	3127	176	1880	3682	4199	2820	12581	—	2864	574	5095	3187	169	1658	3532	3945	2754	11889

ROSS AND CROMARTY.

Parish	BOYS											GIRLS									
	Hair					Eyes				Totals	District	Hair					Eyes				Totals
	Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark			Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark	
Alness	1	3	6	2	0	3	8	1	0	12	*93*	2	2	4	0	0	0	3	5	0	8
Applecross	36	11	51	20	11	22	51	33	23	129	*99*	41	11	35	29	1	19	48	36	14	117
Avoch	47	7	43	35	0	47	16	42	27	132	*93*	57	3	64	22	0	47	23	39	37	146
Barvas	91	5	87	41	7	56	79	34	62	231	*108*	80	7	87	49	6	57	75	39	58	229
Carnoch	2	0	3	4	0	0	4	5	0	9	*93*	6	0	3	5	0	2	7	4	1	14
Contin	0	0	5	1	0	1	1	3	1	6	*93*	1	0	4	2	0	1	2	2	2	7
Cromarty	1	0	10	8	0	1	7	10	1	19	*93*	5	0	23	0	0	2	18	7	1	28
Dingwall	93	18	95	91	6	60	101	73	69	303	*93*	96	16	86	89	13	60	89	80	71	300
Fearn	31	5	35	51	2	2	50	50	22	124	*95*	31	4	44	47	2	1	46	48	33	128
Fodderty	32	5	62	37	0	26	49	41	20	136	*93*	34	7	60	30	1	24	34	54	20	132
Gairloch	56	11	100	90	8	51	103	73	38	265	*99*	63	12	90	60	9	42	89	58	45	234
Glenshiel	6	0	6	6	0	1	7	6	4	18	*99*	9	1	10	4	0	1	7	13	3	24
Killearnan	18	0	25	18	1	8	20	22	12	62	*93*	21	2	18	17	2	3	19	25	13	60
Kilmuir Easter ...	35	5	26	11	7	21	30	20	13	84	*95*	37	3	19	20	2	24	27	22	8	81
Kincardine	12	7	13	23	0	8	11	25	11	55	*96*	21	2	18	16	2	14	22	16	7	59
Kinloch Luichart ...	10	0	9	11	0	12	3	9	6	30	*93 & 99*	18	1	5	12	1	16	7	7	7	37
Knockbain	15	4	28	26	5	18	16	22	22	78	*93*	22	1	38	27	2	22	20	24	24	90
Lochalsh	28	9	38	31	4	30	11	44	25	110	*99*	29	2	17	34	1	20	9	32	22	83
Lochbroom	71	21	83	70	4	21	81	92	55	249	*99*	82	15	62	60	4	29	73	79	42	223
Lochcarron	3	2	11	14	0	1	9	14	6	30	*99*	5	3	16	16	2	10	15	7	10	42
Lochs	149	19	142	139	5	85	168	115	86	454	*108*	147	19	117	123	12	86	132	99	101	418
Logie Easter	3	4	16	15	6	25	9	7	3	44	*95*	10	0	9	9	4	20	2	6	4	32
Nigg	19	0	23	20	0	13	9	26	14	62	*93*	19	0	15	21	0	19	9	15	12	55
Resolis	20	2	28	11	0	16	24	20	1	61	*93*	25	0	32	30	6	29	25	34	5	93
Rosemarkie	44	8	62	40	2	27	49	49	31	156	*93*	52	6	53	35	0	26	60	34	26	146
Rosskeen	24	8	53	43	2	7	55	49	19	130	*95*	45	13	58	43	2	11	65	59	26	161
Stornoway	121	47	324	143	10	104	152	242	147	645	*108*	131	46	275	156	9	97	115	267	138	617
Tain	39	12	71	54	5	30	59	61	31	181	*95*	36	8	56	43	1	19	53	41	31	144
Tarbat	31	5	54	35	1	36	26	42	22	126	*95*	35	2	54	47	1	35	25	41	38	139
Uig	146	19	162	67	9	117	118	103	65	403	*108*	111	17	125	60	9	93	89	91	49	322
Urquhart and Logie Wester	38	10	65	50	2	17	55	47	46	165	*93*	47	8	53	45	0	18	46	46	43	153
Urray	53	9	41	34	0	37	47	41	12	137	*93*	45	10	45	28	0	32	49	39	8	128
Totals	1275	256	1777	1241	97	903	1428	1421	894	4646	—	1363	221	1595	1179	92	879	1303	1369	899	4450

ROXBURGH.

Parish	BOYS											GIRLS									
	Hair					Eyes				Totals	District	Hair					Eyes				Totals
	Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark			Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark	
Ancrum	26	4	40	17	0	22	15	19	31	87	*39*	23	2	16	11	0	19	5	11	17	52
Bedrule	3	2	7	6	0	2	6	10	0	18	*39*	2	0	1	1	0	1	1	2	0	4
Bowden	5	6	16	14	1	3	19	9	11	42	*39*	10	4	18	13	2	7	19	7	14	47
Castleton	3	3	15	3	0	0	11	11	2	24	*37*	3	2	7	6	0	3	8	5	2	18
Cavers and Kirkton ...	28	2	43	20	0	7	37	25	24	93	*38*	28	4	30	14	1	3	29	26	19	77
Crailing	2	0	18	3	0	0	15	6	2	23	*39*	8	0	18	3	0	6	18	1	4	29
Eckford	9	1	10	2	0	10	1	11	0	22	*39*	12	0	10	0	0	9	0	11	2	22
Edgerston	2	0	6	5	2	0	3	8	4	15	*39*	3	2	13	8	1	0	2	20	5	27
Ednam	18	4	34	5	2	10	32	12	9	63	*39*	20	3	16	5	2	6	17	7	16	46
Hawick (Burgh) ...	254	50	336	175	11	122	266	270	168	826	*38*	244	41	324	169	8	122	241	231	192	786
„ (Landward) ...	25	6	25	22	1	11	43	7	18	79	*38*	26	6	14	19	2	5	32	14	16	67
Hobkirk	5	5	30	6	0	23	14	5	4	46	*39*	6	0	25	7	0	16	10	10	2	38
Jedburgh	113	30	110	86	4	73	93	69	108	343	*39*	84	21	101	69	2	47	86	64	80	277
„ (Landward)...	9	4	17	9	0	8	6	16	9	39	*39*	10	0	16	18	1	10	5	25	5	45
Kelso	43	3	73	44	0	33	42	49	39	163	*39*	43	15	51	52	1	42	43	34	43	162
Lilliesleaf	17	4	13	13	3	17	8	10	15	50	*39*	22	2	12	11	4	14	14	12	11	51
Linton	8	1	6	11	1	3	8	13	3	27	*39*	2	2	12	7	0	6	7	2	8	23
Makerstoun	9	0	16	5	0	3	7	8	12	30	*39*	8	1	10	9	2	2	9	8	11	30

TABLE XV.—(*continued*).

County and Parish Data.

ROXBURGH.—(*continued*).

Parish	BOYS										District	GIRLS									
	Hair					Eyes				Totals		Hair					Eyes				Totals
	Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark			Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark	
Maxton	4	1	8	14	0	13	2	5	7	27	*39*	8	1	11	5	0	4	10	6	5	25
Melrose	63	20	158	62	3	50	92	97	67	306	*39*	77	17	117	56	5	40	78	91	63	272
Minto	7	0	22	3	0	0	11	11	10	32	*39*	6	1	26	2	0	0	9	18	8	35
Morebattle	22	2	21	7	1	15	16	19	3	53	*39*	16	4	12	8	1	0	16	19	6	41
Oxnam	3	0	6	5	0	1	6	4	3	14	*39*	2	0	4	4	0	0	3	2	5	10
Roberton	15	3	10	13	0	4	16	11	10	41	*38*	10	1	7	9	1	5	7	7	9	28
Roxburgh	11	2	25	22	2	13	6	17	26	62	*39*	22	0	22	15	0	10	19	19	11	59
St Boswell's	10	3	15	17	0	8	11	10	16	45	*39*	13	1	21	9	0	9	10	10	15	44
Smailholm	13	2	12	4	0	7	20	2	2	31	*39*	20	1	11	10	0	0	26	10	6	42
Southdean	9	2	16	14	0	6	11	12	12	41	*39*	14	5	8	14	1	9	13	12	8	42
Sprouston	21	3	17	19	0	22	16	5	17	60	*38*	17	4	12	12	0	17	13	5	10	45
Teviothead	12	0	5	6	1	6	6	5	7	24	*39*	18	2	9	6	1	8	15	4	9	36
Yetholm	25	5	25	7	0	1	24	26	11	62	*39*	23	5	30	15	0	3	25	30	15	73
Totals	794	168	1155	639	32	493	863	782	650	2788	---	800	147	984	587	35	423	790	723	617	2553

SELKIRK.

Parish	Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark	Totals	District	Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark	Totals
Ashkirk	13	0	13	5	0	6	9	9	7	31	*38*	7	1	7	4	0	4	7	3	5	19
Caddonfoot	15	2	15	15	0	25	6	9	7	47	*40*	15	2	6	12	0	11	8	7	9	35
Ettrick	7	1	6	5	0	1	9	6	3	19	*40*	3	3	10	3	0	0	7	9	3	19
Galashiels (Burgh) ...	200	48	439	137	12	125	179	349	183	836	*40*	216	40	335	110	10	116	178	279	138	711
,, (Landward)	3	0	2	4	0	2	4	2	1	9	*40*	3	2	4	1	1	1	5	2	3	11
Kirkhope	15	3	9	11	2	2	18	7	13	40	*40*	8	1	9	14	0	3	14	5	10	32
Selkirk (Burgh) ...	50	11	85	36	0	47	40	65	30	182	*40*	37	11	98	54	0	40	43	70	47	200
,, (Landward) ...	5	1	7	6	0	10	4	4	1	19	*40*	9	3	8	2	1	13	7	2	1	23
Yarrow	12	2	15	10	0	5	8	10	16	39	*40*	11	0	7	9	0	4	7	7	9	27
Totals	320	68	591	229	14	223	277	461	261	1222	—	309	63	484	209	12	192	276	384	225	1077

STIRLING.

Airth	31	6	64	31	2	23	38	37	36	134	*61*	50	3	58	24	1	27	31	45	33	136
Baldernock	0	4	9	16	0	4	15	9	1	29	*12*	7	5	17	11	0	6	16	13	5	40
Buchanan	7	2	7	11	2	4	5	5	15	29	*59*	10	0	11	9	1	8	11	5	7	31
Campsie	23	5	43	30	0	1	50	42	8	101	*12*	18	4	51	12	0	1	46	28	10	85
Denny	167	34	361	214	15	141	211	266	173	791	*63*	187	24	326	196	25	136	176	259	187	758
Drymen	18	0	32	31	2	16	14	18	35	83	*59*	16	3	42	25	4	27	25	14	24	90
Dunipace	15	0	9	4	1	5	4	15	5	29	*62*	7	0	7	0	0	1	6	7	0	14
Falkirk (Burgh) ...	262	44	521	303	12	179	331	333	299	1142	*62*	231	43	450	300	9	162	297	314	260	1033
,, (Landward) ...	54	7	66	38	4	33	61	43	32	169	*63*	40	6	60	37	2	20	53	38	34	145
Fintry	9	1	2	18	2	7	9	4	12	32	*59*	8	5	3	6	1	1	10	5	7	23
Gargunnock	28	1	16	14	0	21	20	11	7	59	*59*	12	0	9	4	0	9	12	2	2	25
Grangemouth	307	70	475	326	26	242	326	386	250	1204	*61*	305	57	375	254	13	200	273	305	226	1004
Kilsyth (Town) ...	184	34	344	180	2	73	286	231	154	744	*12*	182	41	348	153	2	42	314	230	140	726
,, (Landward) ...	75	18	54	83	2	63	47	59	63	232	*12*	68	11	74	55	4	53	46	55	58	212
Kippen...	6	3	49	13	0	7	24	20	20	71	*59*	24	4	47	10	0	8	32	16	29	85
Larbert	308	79	590	377	18	161	396	533	282	1372	*62*	325	62	567	329	16	179	371	485	264	1299
Logie	26	1	12	10	1	5	24	13	8	50	*59*	20	1	12	13	0	13	15	8	10	46
Muiravonside	133	20	198	120	7	91	134	154	99	478	*61*	155	18	152	116	10	88	147	105	111	451
St Ninians	185	24	157	100	4	98	187	107	78	470	*59*	172	25	147	95	3	96	179	101	66	442
Slamannan	125	33	283	138	2	63	167	251	100	581	*10*	127	23	223	115	0	52	141	193	102	488
Stirling (Burgh) ...	307	78	699	340	23	150	453	502	342	1447	*60*	374	60	695	357	12	165	442	515	376	1498
Strathblane	15	1	23	17	2	12	75	19	12	58	*12*	13	2	27	14	2	16	18	6	18	58
Totals	2285	465	4014	2414	127	1399	2817	3057	2032	9305	—	2351	397	3701	2135	105	1310	2661	2749	1969	8689

SUTHERLAND.

Assynt	19	9	36	14	0	14	30	16	18	78	*96*	41	6	30	17	1	18	37	11	29	95
Clyne	42	6	54	36	3	21	40	37	43	141	*96*	55	4	51	27	1	23	45	28	42	138
Creich	14	12	52	28	2	19	27	31	31	108	*96*	16	8	30	16	3	12	26	15	20	73
Dornoch	47	11	77	51	8	14	63	67	50	194	*95*	43	7	71	46	7	18	32	64	60	174
Durness	16	7	3	12	1	5	16	12	6	39	*96*	13	4	10	12	1	7	13	14	6	40
Eddrachillis	21	4	40	32	1	19	18	41	20	98	*96*	33	3	38	24	1	32	26	23	18	99
Farr	65	14	49	37	0	51	31	51	32	165	*96*	56	15	71	29	1	40	40	60	32	172
Golspie	22	7	50	58	0	7	37	60	33	137	*95*	20	3	59	41	0	3	38	49	33	123
Kildonan	26	6	53	71	0	35	21	56	44	156	*96*	48	5	48	48	0	47	22	39	41	149
Lairg	1	0	5	8	0	5	4	4	1	14	*96*	5	0	1	1	0	2	4	0	1	7
Loth	4	4	14	6	0	6	12	3	7	28	*95*	13	1	10	5	0	9	9	2	9	29
Rogart	24	4	8	25	0	26	11	15	9	61	*96*	36	4	16	13	1	18	22	18	12	70
Tongue	15	7	53	30	2	14	41	25	27	107	*96*	25	1	47	24	0	13	33	21	30	97
Totals	316	91	494	408	17	236	351	418	321	1326	—	404	61	482	303	16	242	347	344	333	1266

TABLE XV.—*(continued).*

County and Parish Data.

ROXBURGH.—*(continued).*

	BOYS											GIRLS									
Parish	Hair					Eyes				Totals	District	Hair					Eyes				Totals
	Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark			Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark	
Maxton	4	1	8	14	0	13	2	5	7	27	*39*	8	1	11	5	0	4	10	6	5	25
Melrose	63	20	158	62	3	50	92	97	67	306	*39*	77	17	117	56	5	40	78	91	63	272
Minto	7	0	22	3	0	0	11	11	10	32	*39*	6	1	26	2	0	0	9	18	8	35
Morebattle	22	2	21	7	1	15	16	19	3	53	*39*	16	4	12	8	1	0	16	19	6	41
Oxnam	3	0	6	5	0	1	6	4	3	14	*39*	2	0	4	4	0	0	3	2	5	10
Roberton	15	3	10	13	0	4	16	11	10	41	*38*	10	1	7	9	1	5	7	7	9	28
Roxburgh	11	2	25	22	2	13	6	17	26	62	*39*	22	0	22	15	0	10	19	19	11	59
St Boswell's	10	3	15	17	0	8	11	10	16	45	*39*	13	1	21	9	0	9	10	10	15	44
Smailholm	13	2	12	4	0	7	20	2	2	31	*39*	20	1	11	10	0	0	26	10	6	42
Southdean	9	2	16	14	0	6	11	12	12	41	*39*	14	5	8	14	1	9	13	12	8	42
Sprouston	21	3	17	19	0	22	16	5	17	60	*38*	17	4	12	12	0	17	13	5	10	45
Teviothead	12	0	5	6	1	6	6	5	7	24	*39*	18	2	9	6	1	8	15	4	9	36
Yetholm	25	5	25	7	0	1	24	26	11	62	*39*	23	5	30	15	0	3	25	30	15	73
Totals	794	168	1155	639	32	493	863	782	650	2788	—	800	147	984	587	35	423	790	723	617	2553

SELKIRK.

Parish	Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark	Totals	District	Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark	Totals
Ashkirk	13	0	13	5	0	6	9	9	7	31	*38*	7	1	7	4	0	4	7	3	5	19
Caddonfoot	15	2	15	15	0	25	6	9	7	47	*40*	15	2	6	12	0	11	8	7	9	35
Ettrick	7	1	6	5	0	1	9	6	3	19	*40*	3	3	10	3	0	0	7	9	3	19
Galashiels (Burgh) ...	200	48	439	137	12	125	179	349	183	836	*40*	216	40	335	110	10	116	178	279	138	711
„ (Landward)	3	0	2	4	0	2	4	2	1	9	*40*	3	2	4	1	1	1	5	2	3	11
Kirkhope	15	3	9	11	2	2	18	7	13	40	*40*	8	1	9	14	0	3	14	5	10	32
Selkirk (Burgh) ...	50	11	85	36	0	47	40	65	30	182	*40*	37	11	98	54	0	40	43	70	47	200
„ (Landward) ...	5	1	7	6	0	10	4	4	1	19	*40*	9	3	8	2	1	13	7	2	1	23
Yarrow	12	2	15	10	0	5	8	10	16	39	*40*	11	0	7	9	0	4	7	7	9	27
Totals	320	68	591	229	14	223	277	461	261	1222		309	63	484	209	12	192	276	384	225	1077

STIRLING.

Parish	Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark	Totals	District	Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark	Totals
Airth	31	6	64	31	2	23	38	37	36	134	*61*	50	3	58	24	1	27	31	45	33	136
Baldernock	0	4	9	16	0	4	15	9	1	29	*12*	7	5	17	11	0	6	16	13	5	40
Buchanan	7	2	7	11	2	4	5	5	15	29	*59*	10	0	11	9	1	8	11	5	7	31
Campsie	23	5	43	30	0	1	50	42	8	101	*12*	18	4	51	12	0	1	46	28	10	85
Denny	167	34	361	214	15	141	211	266	173	791	*63*	187	24	326	196	25	136	176	259	187	758
Drymen	18	0	32	31	2	16	14	18	35	83	*59*	16	3	42	25	4	27	25	14	24	90
Dunipace	15	0	9	4	1	5	4	15	5	29	*62*	7	0	7	0	0	1	6	7	0	14
Falkirk (Burgh) ...	262	44	521	303	12	179	331	333	299	1142	*62*	231	43	450	300	9	162	297	314	260	1033
„ (Landward) ...	54	7	66	38	4	33	61	43	32	169	*63*	40	6	60	37	2	20	53	38	34	145
Fintry	9	1	2	18	2	7	9	4	12	32	*59*	8	5	3	6	1	1	10	5	7	23
Gargunnock	28	1	16	14	0	21	20	11	7	59	*59*	12	0	9	4	0	9	12	2	2	25
Grangemouth	307	70	475	326	26	242	326	386	250	1204	*61*	305	57	375	254	13	200	273	305	226	1004
Kilsyth (Town) ...	184	34	344	180	2	73	286	231	154	744	*12*	182	41	348	153	2	42	314	230	140	726
„ (Landward) ...	75	18	54	83	2	63	47	59	63	232	*12*	68	11	74	55	4	53	46	55	58	212
Kippen	6	3	49	13	0	7	24	20	20	71	*59*	24	4	47	10	0	8	32	16	29	85
Larbert	308	79	590	377	18	161	396	533	282	1372	*62*	325	62	567	329	16	179	371	485	264	1299
Logie	26	1	12	10	1	5	24	13	8	50	*59*	20	1	12	13	0	13	15	8	10	46
Muiravonside	133	20	198	120	7	91	134	154	99	478	*61*	155	18	152	116	10	88	147	105	111	451
St Ninians	185	24	157	100	4	98	187	107	78	470	*59*	172	25	147	95	3	96	179	101	66	442
Slamannan	125	33	283	138	2	63	167	251	100	581	*10*	127	23	223	115	0	52	141	193	102	488
Stirling (Burgh) ...	307	78	699	340	23	150	453	502	342	1447	*60*	374	60	695	357	12	165	442	515	376	1498
Strathblane	15	1	23	17	2	12	75	19	12	58	*12*	13	2	27	14	2	16	18	6	18	58
Totals	2285	465	4014	2414	127	1399	2817	3057	2032	9305	—	2351	397	3701	2135	105	1310	2661	2749	1969	8689

SUTHERLAND.

Parish	Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark	Totals	District	Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark	Totals
Assynt	19	9	36	14	0	14	30	16	18	78	*96*	41	6	30	17	1	18	37	11	29	95
Clyne	42	6	54	36	3	21	40	37	43	141	*96*	55	4	51	27	1	23	45	28	42	138
Creich	14	12	52	28	2	19	27	31	31	108	*96*	16	8	30	16	3	12	26	15	20	73
Dornoch	47	11	77	51	8	14	63	67	50	194	*95*	43	7	71	46	7	18	32	64	60	174
Durness	16	7	3	12	1	5	16	12	6	39	*96*	13	4	10	12	1	7	13	14	6	40
Eddrachillis	21	4	40	32	1	19	18	41	20	98	*96*	33	3	38	24	1	32	26	23	18	99
Farr	65	14	49	37	0	51	31	51	32	165	*96*	56	15	71	29	1	40	40	60	32	172
Golspie	22	7	50	58	0	7	37	60	33	137	*95*	20	3	59	41	0	3	38	49	33	123
Kildonan	26	6	53	71	0	35	21	56	44	156	*96*	48	5	48	48	0	47	22	39	41	149
Lairg	1	0	5	8	0	5	4	4	1	14	*96*	5	0	1	1	0	2	4	0	1	7
Loth	4	4	14	6	0	6	12	3	7	28	*95*	13	1	10	5	0	9	9	2	9	29
Rogart	24	4	8	25	0	26	11	15	9	61	*96*	36	4	16	13	1	18	22	18	12	70
Tongue	15	7	53	30	2	14	41	25	27	107	*96*	25	1	47	24	0	13	33	21	30	97
Totals	316	91	494	408	17	236	351	418	321	1326	—	404	61	482	303	16	242	347	344	333	1266

TABLE XV.—(*continued.*)

County and Parish Data.

WIGTOWN.

Parish	BOYS										District	GIRLS									
	Hair					Eyes				Totals		Hair					Eyes				Totals
	Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark			Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark	
Glasserton	19	5	20	32	1	2	34	24	17	77	*33*	22	1	14	21	0	6	29	13	10	58
Inch	34	13	22	30	1	15	42	30	13	100	*32*	35	4	32	35	0	12	50	22	22	106
Kirkcolm	5	5	20	66	2	25	21	37	15	98	*32*	21	5	13	71	5	34	29	26	26	115
Kirkcowan	33	4	41	27	2	31	23	35	18	107	*33*	44	4	38	24	4	40	25	25	24	114
Kirkinner	23	12	46	52	0	23	34	41	35	133	*33*	41	3	40	27	1	25	37	30	20	112
Kirkmaiden	28	8	43	43	2	24	37	26	37	124	*32*	44	6	50	31	1	32	40	37	23	132
Leswalt	20	9	34	19	1	17	11	29	26	83	*32*	17	6	36	20	6	31	13	14	27	85
Mochrum	9	0	12	15	1	4	23	3	7	37	*33*	10	0	19	15	0	5	20	6	13	44
New Luce	2	3	7	1	0	4	2	5	2	13	*32*	8	1	2	1	0	3	3	6	0	12
Old Luce or Glenluce ...	62	11	102	59	4	73	52	64	49	238	*32*	61	9	74	40	3	54	37	62	34	187
Penninghame	29	11	74	27	5	13	34	66	33	146	*33*	46	14	83	46	3	19	60	65	48	192
Portpatrick	33	3	37	13	0	0	19	62	5	86	*32*	27	7	40	21	0	0	18	70	7	95
Stoneykirk	42	6	36	51	6	23	47	44	27	141	*32*	49	4	41	58	6	44	41	43	30	158
Stranraer (Burgh) ...	137	34	280	87	4	94	162	151	135	542	*32*	144	33	224	117	4	76	180	116	150	522
Whithorn	58	6	85	29	2	21	48	65	46	180	*33*	50	9	105	54	0	25	60	71	62	218
Totals	534	130	859	551	31	369	589	682	465	2105	—	619	106	811	581	33	406	642	606	496	2150

TABLE XVI.

Observers and Schools contributing to the Data of the Pigmentation Survey of School Children in Scotland.*

COUNTY OF ABERDEEN.

Burgh of Aberdeen.—Ashley Road, Mr W. Ross (77); Broomhill, Mr R. A. Watson (77); Causewayend, Mr Rose (77); Commerce St., Mr J. Peter (77); Ferryhill, Mr J. D. Anderson (77); Frederick St., ? (77); Hanover St., Mr W. D. McLean (77); King Street, Mr. T. Hynd (77); Kittybrewster, Mr J. McKenzie (77); Marywell Street, Mr W. Fyfe (77); Middle, Mr J. C. Barnett (77); Mile End, Mr J. F. Cruickshank (77); Old Aberdeen, Mr W. B. Duguid (77); Porthill, Mr W. Stewart (77); St Clements Street, Mr D. B. Lothian (77); St Paul Street, Mrs J. S. Skea (77); Skene Square, Mr A. Green (77); Skene Street, ? (77); Westfield, Mr W. Robertson (77); Woodside, Mr J. A. McHardy (77); York Street, Miss Spalding (77); Deaf and Dumb Institution, Mr Alex Pender (77); Normal, U. F. C., ? (77); St Margaret's Mission, Sister Katharine Mary (77); St Peter's, R.C., Mr J. Brady (77); Cathedral, R.C., Mr P. McGrath (77); Gordon's College, Mr C. Stewart (77); Rosemount, Mr J. Findlay (77). Parish of Aberdour—Aberdour, Mr J. Reaich (83); Auchmedden, Mr W. Swanney (83); Parish of Aboyne and Glen Tanar—Aboyne, Mr J. Cruickshank (79); Glen Tanar, Mr W. Walker (79); Parish of Alford—Alford Village, Mr D. C. Crabbe (80); Gallowhill, Mr A. McCreadie (80); Parish of Ardallie—Ardallie, ? (82); Ardallie, Female, Miss J. Kemp (82); Parish of Auchterless—Badenscoth, Mr. Geo. Ironside (82); Kirktown, Mr A. Longmore (82); Parish of Belhelvie—Balmedie, Mr C. E. Glennie (78); Craigie, Miss Fraser (78); Menie, Miss Jane Watt (78); Wester Hatton, Mr M. S. Craib (78); Parish of Birse—Birse, Mr G. Innes (78); Finzean, Mr W. Adams (78); Forest, Miss Eva Shaw (78); Parish of Bourtie—Bourtie, Miss Taylor (80); Parish of Cairney—Alehousehillock, Miss G. Gray (87); Cairney, Mr P. Stuart (87); Ruthven, Mr W. Johnstone (87); Windyraw, Mr A. Middleton (87); Parish of Chapel of Garioch—Chapel, Miss E. J. Fordyce (80); Logie Durno, Mr J. B. Robson (80); Parish of Clatt—Clatt, Mr W. Stewart (80); Parish of Cluny—Cluny, Mr W. Harper (80); Cluny, U. F. C., Miss Deuchars (80); Corennie, Lady Gordon Cathcart's, Miss J. A. Ironside (80); Parish of Coull—Coull, Mr A. Howie (79); Parish of Crathie and Braemar—Aberarder, Miss M. Catto (79); Braemar, Mr J. Badenoch (79); Crathie, Mr W. Brown (79); Crathieside, Mr W. Strath (79); Inverey District, Miss S. MacFarlane (79); Inverey, R. C., Miss M. Dallastone (79); Parish of Cruden—Auchiries, Miss M. Campbell (78); Bogbrae, Mr J. C. Coutts (78); Hatton, Mr W. Littlejohn (78); Errol, Epis., Mr Miller (78); Parish of Culsalmond—Tillymorgan, Mr A. J. Wallace (80); Parish of Drumblade—Drumblade, Mr J. Taylor (87); Parish of Drumoak—Drumoak Central, Mr J. R. Littlejohn (79); Glashmore, Miss J. A. McBeth (79); Parish of Dyce—Dyce Overtown, Miss L. R. Mitchell (80); Dyce village, Mr G. Murray (80); Parish of Echt—Cullerley, Miss M. J. Barron (79); Kirkton, Mr R. C. Burnett (78); Waterton, Miss E. Peace (79); Parish of Ellon—Berefold, Mr R. Thomson (82); Drumwhindle, Mr L. Gavin (82); Ellon, Mr D. Cameron (82); Esslemont, Mr A. Cairns (82); Parish of Fintray—Disblair, Miss J. Meldrum (80); Hatton, Mr C. Smith (80); Parish of Forgue—Forgue, Mr R. Wright (87); Largue, Mr J. Gray (87); Forgue Episc., Miss J. B. Duncan (87); Parish of Foveran—Cultercullen, Mr J. Rose (78); Foveran, Mr J. Watson (78); Newburgh Mathers, Mr Williams (78); Parish of Fraserburgh—Fraserburgh, Mr J. A. Sutor (83); Fraserburgh,

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* The figures in brackets refer to the Districts, where blanks with a query occur, the names of teachers were not supplied.

Infant, Miss Milne (83); Academy, Elementary Dept., Mr R. Lees (83); Broadsea, Mr J. W. Broome (83); Female Industrial, Miss N. Brown (83); St Peter's Episc., Mr J. Gray (83); Parish of Fyvie—Fyvie, Mr A. Bremner (82); Steinmanhill, Miss J. A. Calder (82); Woodhead, Mr D. Davidson (82); All Saints' Epis., Mr M. Sangster (82); St Katharine's, Miss A. Forbes (82); Parish of Gartly—Braes, Miss J. W. Emslie (87); Central, Mr W. Smith (87); Parish of Glass—Beldorney, Miss M. M. Duguid (87); Glass, Mr D. Wood (87); Parish of Glenbucket—Glenbucket, Mr J. N. Watt (80); Parish of Glenmuick and Tullich—Ballater, Mr J. Lawson (79); Birkhall, Miss A. Begg (79); Inchmarnock—Miss C. Forbes (79); Kinnord, Miss R. Begg (79); Parish of Huntly—Gordon, Mr D. M. J. James (87); Kinnoir, Miss A. Allardyce (87); Longhill, Mrs H. Kemp (87); Parish of Insch—Insch, ? (80); Parish of Inverurie—Market Place, Mr J. Philip (80); Infant School, Mr J. Rennie (80); St Mary's Epis., Mr J. Stuart (80); Parish of Keig—Keig, ? (80); Parish of Keithhall and Kinkell—Keithhall, Mr Geo. Kemp (80); Parish of Kennethmont—Kennethmont, Mr G. Cheyne (80); Old Town, Mr P. Campbell (80); Parish of Kincardine O'Neil—Greenburn, Miss J. A. Ogg (79); Kincardine O'Neil, Mr A. T. Ross (79); Tornaveen, Mr P. Wallace (79); Torphins, Mr J. W. Williams (79); Parish of King Edward—King Edward, Mr J. Elphinstone (86); Parish of Kininmonth—Kininmonth, Mr G. M. Farquharson (84); Parish of Kinellar—Kinellar, Mr A. Forrest (80); Parish of Kintore—Kintore, Mr W. Keys (80); Leylodge, Miss A. Riach (80); Port Elphinstone—Mr J. Ritchie (80); Parish of Leochel Cushnie—Cairncoullie, Mr G. Shearer (80); Corse, Mr E. S. Mearns (80); Craigievar, Mr A. Grassick (80); Cushnie, ? (80); Parish of Leslie—Leslie, Mr G. Riddell (80); Parish of Logie Buchan—Tipperty, Mr L. Smart (78); Parish of Logie Coldstone—Logie Coldstone, Mr J. B. Anderson (79); Migvie, Miss E. Robertson (79); Parish of Longside—Kinmundy, Mr. A. McD. Younie (84); Longside, Mr A. Center (84); Rora, Mr A. F. Annand (84); Parish of Lonmay—Blackhills, Mr L. McLeod (83); Lonmay, Mr J. S. Ewen (83); St Combs, Mr R. Mirrless (83); Parish of Lumphanan—Lumphanan, Mr R. McLean (79); Parish of Meldrum—Commercial Road, Mr C. F. Bearsley (82); Kirk St., Infant, Miss McRae (82); Tulloch, Miss M. Cooper (82); Parish of Methlick—Cairnorrie, Mr J. Macdonald (82); Methlick, Mr A. C. Kirton (82); Parish of Midmar—Midmar and Corsindae Memorial, Mr J. Grant (79); Parish of Millbrex—Millbrex, Male, Mr. P. McDonald (82); Millbrex District, Mr E. Ironside (82); Parish of Monquhitter—Garmond, Miss M. A. Lyall (82); Greeness, Mr J. M. Stephen (82); Monquhitter, Mr W. Barclay (82); Parish of Monymusk—Monymusk, Mr A. W. Simpson (80); Sir Arthur Grant's, Miss E. M. Scott (80); Tillyfourie, Miss M. Main (80); Parish of New Byth—New Byth, Mr M. A. Clark (86); Upper Brae, Miss J. Wilson (86); Parish of New Deer—Cairnbanno, Mr J. Macpherson (84); Knaven, Mr W. Hadden (84); New Deer, Mr H. Cowie (84); do. Infant, Miss Morrison (84); Oldwhat, Mr A. Dunbar (84); Whitehill, Mr G. Greig (84); Bonnykelly, Miss A. B. Oliphant (84); Parish of Newhills—Blackburn, Mr J. Ligertwood (78); Bucksburn, Mr M. G. Gerrard (78); Kepplehills, Miss Jackson (78); Kingswells, Mr D. J. Williamson (78); Stoneywood, Mr C. Frazer (78); Parish of New Machar—New Machar, Mr J. G. Moncur (78); Parkhill, Miss A. J. Crane (78); Whiterashes, Mr J. McGregor (78); Parish of New Pitsligo—Glasslaw, Miss E. Davidson (84); New Pitsligo, Mr J. Will (84); St John's Episc., Miss Fowlie (84); Parish of Old Deer—Bulwark, Miss Watters (84); Clochan, Mr R. D. Robertson (84): Fetterangus, Mr. W. Scorgie (84); Maud, Mr J. Law (84); Old Deer, Mr J. B. Gillies (84); Shannas, Mr P. S. Pyper (84); Stuartfield, Miss S. M. Thomson (84); Parish of Old Machar—Bridge of Don, Miss B. W. Killoh (78); Denmore, Miss A. Robertson (78); Whitestripes, Miss A. Dey (78); Parish of Oyne—Oyne, Mr Riddell (80); Parish of Peterculter—Countesswells, Miss A. M. Duncan (78); Craigton, Mr D. A. Farquhar (78); Cults, Mr F. Croll (78); Eddieston, Miss J. Rennie (78); Burgh of Peterhead—Academy, Mr J. Don (81); Buchanhaven, Miss J. C. King (81); Central, Mr A. McD. Reid (81); Infant, Miss A. Forbes (81); North, Mr W. Murray (81); North, Infant, Miss E. Barclay (81); St Peter's Epis., Miss E. Bruce (81); Parish of Peterhead (Landward)—Blackhills, Mr W. Smith (81); Boddam, Mr S. McKim (81); Burnhaven, Mr D. J. Mitchell (81); Parish of Pitsligo—Pitsligo, Miss H. Strachan (83); Rosehearty, Mr A. Forbes (83); Sandhaven, Mr W. J. Caird (83); Parish of Premnay—

Premnay, Mr W. L. H. Cruickshank (80); Parish of Rathen--Inverallochy, Mr D. C. Dundas (13); Rathen, Mr J. Jack (83); Cortes, Mr E. Cowie (83); Parish of Rayne—North, Mr W. Black (80); Old Rayne, Miss M. U. Morrice (80); Parish of Rhynie—Duffs, Miss A. M^cGillivray (87); Lesmore, ? (87); Parish of St Fergus—Central, Mr J. Cormack (81); Northern, Miss J. Gall (81); Parish of Savoch—Braeside, Mr W. Ferguson (82); Savoch, Girls, Miss E. Penny (82); Parish of Skene—Central, Mr G. Mitchell (79); Garlogie, Miss J. F. Harper (79); Westhill, Miss A. Mackie (79); Parish of Slains—Collieston, Miss H. Leslie (78); Slains, Mr Harper (78); Parish of Strathdon—Corgarff, Mr A. Merriless (80); Forbeston, Miss F. Rennie (80); Knocklea, Mr J. Forbes (80); Strathdon, Mr J. B. Innes (80); Tillyduke, Mr C. Farquharson (80); Parish of Strichen—Strichen, Miss J. Aiken (84); Techmuiry 2nd, Mr P. Seath (84); All Saints' Epis., Miss M. J. Greig (84); Parish of Tarland—Tarland, Mr J. Forbes (79); Parish of Tarves—Auchedly, Miss C. P. Hay (82); Barthol Chapel, Mr. W. Wilson (82); Craigdam, Mr J. Davidson (82); Parish of Tough—Tough, Mr Chas. Stewart (80); Parish of Towie—Ardlair, Miss J. Collie (80); Towie, Mr J. M^cLean (80); Parish of Turriff—Ardmiddle, Mr J. Roy (86); Birkenhills, Mr J. Dilworth (86); Fintry, Mr J. Clark (86); Turriff, Mr D. L. Phease (86); Parish of Tyrie—Tyrie, Mr A. Coppland (84); Parish of Udny—Udny Green, Mr W. Sim (82); Parish of Ythan Wells—Corse, Miss J. Tocher (82); Ythan Wells, Mr J. M^cPherson (82).

COUNTY OF ARGYLL.

Parish of Acharacle—Eilanshona, Mr J. M^cGregor (100); Glenborrodale, Miss A. F. Cameron (100); Kinlochmoidart, Miss J. J. Macnaughton (100); Mingarry, Miss K. Edmonson (100); Parish of Ardchattan and Muckairn—Achaleven, Mr W. W. Ewing (101); Glenetive, Mr K. J. Robson (101); Letterwood, Miss A. Connell (101); Parish of Ardgour—Ardgour, Miss Stuart (100); Duisky, Miss A. M^cMillan (100); Trislaig, Miss A. Campbell (100); Kingairloch, Miss C. M^cMillan (100); Parish of Ardnamurchan—Kilchoan, Mr A. C. Storrer (100); Burgh of Campbeltown—Dalintober, Mr D. Fisher (103); Grammar, Mr R. Y. Cunningham (103); Millknowe, Mr J. Kirkwood (103); St Kierans, R. C., Miss T. Fisher (103); Parish of Campbeltown (Landward)—Auchencorvie, Mr J. Templeton (103); Drumlemble, Mr D. Cameron, Kilmichael, Mr W. H. Edgar (103); Peninver, Mr D. M. M^cNeil (103); Parish of Coll—Acha, Miss M. Tyre (100); Arinagour, Mr R. MacTaggart (100); Cornaig, Mr T. Johnston (100); Parish of Colonsay and Oronsay—Kilchattan, Miss J. Campbell (102); Parish of Craignish—Craignish, Mr J. Kay (101); Barbreck, Miss M. Ferguson (101); Parish of Cumlodden—Furnace, Mr W. G. M^cKinlay (101); Parish of Dunoon and Kilmun—Ardentinny, Mrs M. C. Giffen (104); Dunoon Grammar, Mr W. Dock (104); Glenlean, ? (104); Innellan, Mr D. Ritchie (104); Kirn, Mr J. Connell (104); Rashfield, Miss J. Bruce (104); Sandbank, Mr A. M^cNeilage (104); Strone, Mr W. Baird (104); Parish of Gigha and Cara—Gigha, Mr T. Scott (102); Parish of Glassary—Cairnbaan, Miss S. M^cIntyre (101); Glassary, Mr J. Pemmell (101); Minard, Mr G. Nicolson (101); Parish of Glenaray and Inveraray—Bridge of Douglas, Miss Gibson (101); Parish of Glenorchy and Inishail—Bridge of Orchy, Mrs MacLaine (101); Cladich, Miss C. Russell (101); Dalmally, Mr J. Macdonald (101); Parish of Inverchaolain—Inverchaolain, Mr T. M^cNab (104); South Hall, Miss J. B. Fraser (104); Parish of Jura—Ardlussa, Miss M. B. Spiers (102); Knockrome, Mr G. H. Fisher (102); Small Isles, Mr W. M^cLintock (102); Parish of Kilbrandon and Kilchattan—Ardincaple, Miss A. Mackay (101); Luing, Mr C. Clubb (101); North Luing, Miss M. Orr (101); Parish of Kilcalmonell, Clachan, Mr J. Mackie (102); Whitehouse, Mr J. Ross (102); Parish of Kilchoman—Gortan, Mr A. Mackay (102); Kilchoman, Mr A. R. Scott (102); Kilnave, Miss M. R. Hayes (102); Port Charlotte, Mr A. M^cDougall (102); Portnahaven, Mr N. Orr (102); Rockside, Miss M. Ferguson (102); Parish of Kilchrenan and Dalavich—Ardchonnell, Mr J. M^cLeod (101); Dalavich, Miss M. Smith (101); Kilchrenan, Mr W. L. Bruce (101); Sonachan, Miss J. G. M^cKenzie (101); Parish of Kildalton—Ardbeg, Mr H. Bisset (102); Glenegidale, Miss

M. Bell (102); Kintour, Mr J. Marnie (102); Oa, Miss MacDougall (102); Port Ellen, Mr D. McLachlan (102); Parish of Kilfinan—Ardlamont, Miss Simpson (102); Kilfinan, Mr J. MacCallum (102); Millhouse, Mr D. McDonald (102); Otter Ferry, Mrs W. Stewart (102); Tighnabruaich, Mr A. Barrett (102); Parish of Kilfinichen and Kilvickeon—Ardchevaig, Mr A. R. Campbell (100); Bunessan, Mr J. McMaster (100); Creich, Mr A. Stewart (100); Erraid, Miss G. McKechnie (100); Iona, Mr Jas. Wood (100); Pennyghael, Miss C. L. Pagan (100); Parish of Killarrow and Kilmeny—Bowmore, Mr J. Bryce (102); Kiels, Miss M. E. Falconer (102); Kilmeny, Mr W. McFadyen (102); Mulindry, Mr D. MacBean (102); Newton of Kilmeny, Mr W. P. Cameron (102); Parish of Killean and Kilchenzie—Ballochintee, Miss J. McGibbon (103); Glenbarr, Mr W. Agnew (103); Kilchenzie, Mr W. McCulloch (103); Killean, Miss C. Livingston (103); Rhunahaorine, Mr W. Bain (103); Parish of Kilmodan—Kilmodan, Mr J. MacInnes (104); Stronafian, Mr P. A. Munro (104); Parish of Kilmore and Kilbride—Kerrera, Miss M. Rodger (101); Strontoiller, Miss F. C. Sinclair (101); Parish of Kilninian and Kilmore—Fanmore, Miss G. Warnock (100); Morinish, Miss M. Clark (100); Tobermory, Mr J. S. Levack (100); Parish of Kilninver and Kilmelford—Kilmelford, Miss J. B. Robertson (101); Parish of Lismore and Appin—Balachulish, Mr A. McCallum (101); Baligarve, Mr J. Wilson (101); Baligrundle, Mrs Campbell (101); Duror, Mr R. Macgregor (101); Glencreran, Miss M. McKenzie (101); Lettermore, ? (101); Port Appin, Miss A. McGlashan (101); Strath of Appin, Mr D. Macpherson (101); Carnock, Glencoe St Mary's Episcopal, Miss Janet Stewart (101); Parish of Lochgilphead—Ardrishaig, Mr A. Ramsay (101); Parish of Lochgoilhead and Kilmorich—Kilmorich, Mr J. B. Logan (101); Lochgoilhead, Mr W. Gilchrist (101); Parish of Morvern—Bunavullin, Miss H. Stewart (100); Claggan, Miss J. Robertson (100); Lochaline, Mr D. B. Fletcher (100); Parish of North Knapdale—Bellanoch, Mr A. Dixon (102); Parish of Oban; Burgh, High, Mr J. Beattie (101); Parish of Saddell and Skipness—Carradale, Mr J. R. McInnes (102); Saddell, Mr W. Jenkins (102); Skipness, Mr T. Johnston (102); Sperasaig, Mr J. S. Barwell (102); Parish of Southend—Glenbreckrie, Mr R. Montgomery (103); Southend, Mr J. Morton (103); Parish of South Knapdale—Auchoish, Miss J. Campbell (102); Dunmore, Mr D. McArthur (102); Inverneil, Miss L. Mactavish (102); Ormsary, Miss K. Blair (102); Parish of Stralachlan and Strachur—Poll, Mr A. N. Sheridan (101); Stralachlan, Miss J. E. Munro (101); Parish of Strontian—Strontian, Mr D. Cameron (100); Parish of Torosay—Crogan, Miss C. McKinnon (100); Kinlochspelve, Miss Mackinnon (100); Lochdonhead, Mr W. G. MacBean (100); Parish of Tyree—Cornaigmore, Mr D. McKinnon (100); Hillipool, Mr G. McDonald (100); Ruaig, Mr D. Gunn (100).

COUNTY OF AYR.

Parish of Alloway—Alloway, Mr J. Turnbull (31); Parish of Ardrossan—Academy, Mr J. Butters (29); Eglinton, Mr W. Comrie (29); Parish of Auchinleck—Auchinleck, Mr J. Henderson (26); Cronberry, Mr Jas. Hyslop (26); Glenmuir, Miss Mary Stuart (26); Lugar, Mr Wm. Hume (26); Ayr Burgh—Grammar, Mr Hy. Robertson (25); Newton on Ayr Academy, ? (25); Russell Street, Mr A. D. Murphy (25); Ayr Episcopal, Mr Jas. Scott (25); St Margaret's, R. C., Mr L. Gemson (25); Parish of Ballantrae—Auchenflower, Mr J. M. Ferguson (32); Ballachdowan, Miss J. S. Dale (32); Glenapp, Miss J. Leask (32); Parish of Barr—Rowantree, Mr J. Brown (31); Parish of Beith—Academy, ? (30); Greenhills, Mr T. Stevenson (30); Gateside, Mr J. J. Bone (30); Parish of Colmonell—Barrhill, Mr D. Millar (32); Colmonell, Mr A. Beattie (32); Corwar, Mrs Weir (32); Lendalfoot, Miss H. Gray (32); Pinwherry, Miss W. Holms (32); Parish of Coylton—Coylton, ? (31); Littlemill, Mr W. Guthrie (31); Parish of Crosshill—Crosshill, Mr Duncan (31); Kilkerran, Hillside, Miss McCreath (31); Parish of Dailly—Kilgrammie, Mr D. Taylor (31); Wallacetown Works, Mr D. Guthrie (31); Parish of Dalmellington—Benwhat, Mr A. McArthur (31); Lethan Hill, Mr D. Vallance (31); Parish of Dalry—Blairmains, Miss J. McR. Deacon (30); West End, Mr D. Campbell (30); Parish of Dalrymple—Dalrymple, Mr A. Lockhead (31); Hollybush, Infant, Miss Johnstone (31); Kerse, Mr A. Lyle (31); Parish of Dreghorn—Dreghorn, Mr Jas. Mair (28); Parish of Dundonald—Dundonald, Mr H. Gibb (28); Loans, Miss J. C. Brown (28); Troon, Portland, Mr W. Scott (28); Troon, St Patrick's, Miss Murphy (28); Parish of Dunlop—Dunlop, Mr A. Brown (30); Parish of Fenwick—Fenwick, Mr W. Brown (30); Parish of Galston—Allanton, Miss Hunter (28); Galston, Mr A. Young (28); Town of Girvan—Girvan, Mr M. J. Finlayson (31); Girvan, H. G., Mr M. J. Finlayson (31); Parish of Girvan (Landward)—Assell, Mr H. Raeburn (31); Doune, Mr J. Eaglesome (31); Girvan, Mr D. Thomson (31); Burgh of Irvine—Bank Street, Mr R. Selkirk (28); Fullarton, ? (28); Fullarton, Loudon Street, Mr W. Mitchell (28); Parish of Irvine (Landward)—Annick Lodge, Mr J. Dunlop (28); Parish of Kilbirnie—Glengarnock, Mr R. Gray (30); Ladyland, Mr J. Fulton (30); Female Industrial, Miss Turnbull (30); St Bridget's, R. C., Mr H. McGrath (30); Parish of Kilmarnock (Landward)—Crooked Holm, Mr T. Duncanson (28); Grougar, Mr C. S. Macdonald (28); Rowallan, Mr J. Clelland (28); Burgh of Kilmarnock—Academy, Dr H. Dickie (27); Academy H. G., Dr H. Dickie (27); Bentinck, Mr D. Walker (27); Glencairn, Mr Thos. Amos (27); Hamilton, Mr G. H. Innes (27); High Street, Mr G. Smith (27); West Netherton, ? (27); Parish of Kilmaurs—Crosshouse, Mr J. Wilson (28); Kilmaurs, Mr D. McNaught (28); Parish of Kilwinning—Auchentiber, Mr H. Paterson (30); Eglinton District, Mr R. Brothertone (30); Kilwinning, Mr W. Blair (30); Parish of Kirkmichael—Kirkmichael, Mr J. Kirkland (31); Parish of Kirkoswald—Townhead, Mr T. Chapel (31); Parish of Largs—Fairlie, Mr H. Allan (23); Parish of Loudoun—Newmilns, Mr A. Hood (28); Parish of Mauchline—Crosshands, Miss C. Mitchell (26); Mauchline, Mr J. Campbell (26); Parish of Maybole and Maybole West Church—Cairn, Mr A. M. Nisbet (31); Ladyland, Mr J. S. Porteous (31); Minishant, Mr J. Clark (31); Parish of Monkton and Prestwick—Monkton, Mr Jas. Howat (26); Prestwick, Mr W. Beaton (26); Parish of Muirkirk—Glenbuck, Mr J. Rodger (26); Wellwood, Miss Bella Ross (26); Parish of New Cumnock—Beoch Side, Miss McLennan (36); Dalleagles, Mr A. H. Mackay (36); New Cumnock, Mr J. A. Wales (36); New Cumnock, R. C., Miss M. Connolly (36); Parish of Ochiltree—Ochiltree, Mr A. Andrew (26); Sinclairston, Mr A. Green (26); Parish of Old Cumnock—Garallan, Mr J. B. Wilson (26); Old Cumnock, Mr J. Dick (26); Skares, Miss J. Wilson (26); Old Cumnock, R. C., ? (26); Parish of Riccarton—Hurlford, Mr H. Andrew (28); Riccarton, Mr A. Inglis (28); Barleith, Miss I. Paterson (28); Parish of St Quivox—St Quivox, Mr A. Moody (26); Parish of Sorn—Auchencloigh, Miss Forrester (26); Catrine, Mr J. Monie (26); Sorn, Mr Ed. Robertson (26); Parish of Stair—Stair, Mr T. E. Scott (26); Parish of Stevenston—Kyles Hill, Mr Geo. Tait (29); Stevenston, Mr J. Taylor (29); Ardeer, Mr W. Reid (29); Parish of Stewarton—Kingsford, Mr W. Hastings (30); Stewarton, Mr A. L. Watt (30); Parish of Straiton—Loch Doon, Mr A. H. Campbell (31); Straiton, Mr W. MacMorland (31); Parish of Symington—Symington, Mr Jas. Currie (26); Parish of Tarbolton—Annbank, Mr J. McArthur (26); Parish of West Kilbride—West Kilbride, Mr J. G. Lyon (23).

COUNTY OF BANFF.

Parish of Aberlour—Aberlour, Mr W. Philip (90); Edenvillie, Mr D. R. Mackay (90); Craigellachie, Miss E. H. McWilliam (90); Parish of Alvah—Alvah, Mr A. Stuart (86); Dunlugas, Miss C. Simpson (86); Linhead, Mr J. H. Fraser (86); Burgh of Banff—Academy, Mr McPherson (85); St Andrew's Epis., Miss I. Marr (85); Parish of Banff (Landward)—Headrooms, Miss Adamson (85); Hilton, Mr A. Scott (85); Parish of Boharm—Boharm, Mr R. Grant (90); Forgie, Miss M. Gill (90); Maggyknockater, Mr T. M. Smith (90); Parish of Botriphnie—Botriphnie, Mr J. Innes (87); Parish of Boyndie—Blairmaud, Miss A. Adamson (85); Boyndie, Mr W. Ledingham (85); Whitehills, Mr Geo. Wilson (85); Parish of Cabrach—Lower, Mr T. Robertson (87); Upper, Mr J. S. Burns (87); Parish of Cullen—Cullen, Mr W. Cramond (85); Parish of Deskford—Deskford, Mr W. Smith (86); Parish of Enzie—Enzie, Mr W. F. Nichol (87); Port Gordon, Mr J. Reid (87); Parish of Fordyce

—Bogmuchals, Miss I. D. Craik (85); Brodiesord, Mr J. A. King (85); Fordyce Academy, Mr A. Emslie (85); Portsoy, ? (85); Sandend, Mr Henry Cumming (85); Portsoy Female Industrial, Miss Liddell (85); Parish of Gamrie—Longmanhill, Mr J. Carine (85); Macduff, Mr D. Renton (85); Macduff Murray's, Mr J. Panton (85); Parish of Glenrinnes—Glenrinnes, Mr S. Wilson (90); Parish of Grange—Grange, Mr J. D. Burns (87); Parish of Inveravon—Glenlivet, Mr T. Laing (91); Inveravon, Mr A. Myron (91); Morinish, Mr D. M. MacDonald (91); Tomnavoulin, Miss M. A. Henderson (91); Ballindalloch, Lady McPherson Grant's, Miss E. S. Myron (91); Tombae, St Mary's, R. C., Miss A. Gordon (91); Parish of Inverkeithney—Easterfield, Miss Jessie Galt (87); Kirktown, Mr J. E. Taylor (87); Parish of Keith—Achanachie, Miss J. A. Henderson (87); Fife Keith, Infant, Miss J. L. Anderson (87); Keith, ? (87); Tarry Croys, Miss M. S. Robertson (87); The Glen, Miss J. Crane (87); Newmill, Mr A. Johnstone (87); Parish of Kirkmichael—Kirkmichael, Miss M. Gordon (91); Parish of Marnoch—Aberchirder, Mr D. Stewart (86); Culvie, Mr J. McIvor (86); Marnoch, Mr W. C. Shand (86); Netherdale, Miss J. Merson (86); Aberchirder Epis., Mr Morgan (86); Parish of Mortlach—Mortlach, ? (90); Parish of Ordiquhill—Ordiquhill, Mr A. Donald (86); Cornhill, Mrs J. M. Kemp (86); Parish of Rathven—Arradoul, Miss E. Johini (85); Buckie, Mr A. Muir (85); Findochty, M. J. Geddes (85); Rathven, Mr J. S. Paterson (85); Buckie, Lady Cathcart's Indust., Miss J. Cocker (85); Parish of Rothiemay—Rothiemay, Mr J. Geddes (87); Ternemny, Mr J. Mackie (87).

COUNTY OF BERWICK.

Parish of Abbey St Bathan's—Abbey St Bathan's, Mr E. J. Wilson (42); Parish of Ayton—Burnmouth, Mr C. M. Alexander (42); Parish of Bunkle and Preston—Preston, Miss Robertson (42); Parish of Channelkirk—Channelkirk, Mr H. M. Liddell (42); Parish of Chirnside—Chirnside, Mr R. Kincaird (42); Parish of Cockburnspath—Ecclaw, Miss Nicholson (42); Parish of Coldingham—Auchincrow, Mr R. Greig (42); Cairnbank, Mr Harris (42); Coldingham, Mr W. Robb (42); Renton, Mr James Greig (42); Reston, Mr W. Dand (42); St Abbs, Mr A. Gibson (42); Parish of Coldstream—Coldstream, Mr D. C. Hardie (42); Parish of Cranshaws—Cranshaws, Mr W. B. Tomison (42); Parish of Duns—Millburn, Mrs E. S. Hopper (42); Parish of Earlston—Mellerstain, Miss A. Shaw (42); Parish of Eccles—Eccles, Mr W. Leitch (42); Parish of Edrom—Allanton, Mr Thomas Anderson (42); Parish of Foulden—Foulden, Mr C. Millar (42); Parish of Gordon—Gordon, Mr J. Leitch (42); Parish of Hume and Stitchell—Hume, Mr A. H. Cuthbert (42); Stitchell, Mr Wm. Smith (42); Parish of Hutton—Hutton, Mr John Brown (42); Paxton, Mr J. Kinross (42); Parish of Ladykirk—Ladykirk, Mr W. Milne (42); Parish of Langton—Langton, Mr J. McDonald (42); Parish of Lauder—Lauder, Mr W. Moore (42); Parish of Legerwood—Legerwood, Mr R. Martin (42); Parish of Longformacus—Longformacus, Mr J. Brown (42); Parish of Mertoun—Mertoun, Mr James Dodds (39); Parish of Mordington—Mordington, Mr Sinclair (42); Parish of Nenthorn—Nenthorn, Mr A. Winton (42); Parish of Polwarth—Polwarth, Mr R. Johnstone (42); Parish of Swinton—Swinton, Mrs Kayne (42); Parish of Westruther—Gateside, Miss C. Harrower (42); Westruther, Mr W. Gibb (42); Parish of Whitsome—Whitsome, Mr A. Brown (42).

COUNTY OF BUTE.

Parish of Cumbrae—Cumbrae, Mr R. Paterson (104); Parish of Kilbride—Brodick, Mr T. Reid (103); Corrie, Mr A. Cameron (103); Lamlash, Mr H. Wilkie (103); Parish of Kilmory—Littlemill, Mr J. D. McKinnon (103); Shiskine, Mr R. T. Irvine (103); Sliddery, Mr J. A. Cook (103); Parish of Kingarth—Birgidale, Miss M. S. Stewart (104); Kerrycroy, Mr W. Fulton (104); Kingarth, Mr W. T. Esplin (104); Mount Stewart, R. C., Mr J. Linsley (104); Parish of North Bute—Ballianlay, Mr J. Duncan (104); Kildavannan, Mrs G. Weir (104); North Bute, Mr P. White (104); Burgh of Rothesay—Academy and Thomson's Institut., Mr J. D. Rose (104); Rothesay, Mr J. McKay (104); St Andrews, R. C., Sister Colette (104).

COUNTY OF CAITHNESS.

Parish of Bower—Bower, Mr D. Crowe (98); Gillock, Miss Bain (98); Stanstill, Mr A. Henry (98); Stemster, Mr J. Watson (98); Parish of Canisbay—Canisbay, Mr A. Munro (97); Freswick, Mr A. R. Forrest (97); John O'Groats, Mr G. F. Mackenzie (97); Mey, Mr Neil J. Leitch (97); Stroma, Mr D. Cormack (97); Parish of Dunnet—Crossroads, Mr W. A. Fowler (98); Dunnet, Mr A. Hay (98); Greenland, Miss M. A. Sutherland (98); Parish of Halkirk—Banniskirk, Miss G. Sinclair (98); Calder, Mr G. Sutherland (98); Harpsdale, Miss J. Noble (98); Leurery, Mr J. McKenzie (98); Spittal, Mr R. A. Morgan (98); Parish of Keiss—Aukengill, Mr G. Stalker (97); Parish of Latheron—Bruan, Mr J. Sutherland (97); Dunbeath, Mr J. Morrison (97); Lybster, Mr J. Mackenzie (97); Wheel, Miss E. M. Ross (97); Parish of Olrig—Castletown, Mr A. S. Robertson (98); Durran, Miss K. M. Cameron (98); Murkle, Mr J. Weir (98); Tain District, Miss J. Coghill (98); Olrig Female, Miss D. Sutherland (98); Parish of Reay—Brubster, Mr D. McLeod (98); Reay, Mr D. Menzies (98); Parish of Thurso—Forss, Mr W. Thom (98); Janetstown Dist., Miss J. Cormack (98); Miller Instit., Mr W. McLaren (98); West, ? (98); Weydale Dist., Mr A. Killin (98); Parish of Watten—Gersa, Mr A. Sutherland (98); Lanergill, Mr A. Malloch (98); West Watten, Mr P. Sutherland (98); Burgh of Wick—Pulteneytown Academy, Mr W. Dick (97); Wick North, Mr Geo. Gunn (97); Wick South, Mr A. S. Fullarton (97); West Banks, Mr C. Fletcher (97); Parish of Wick (Landward)—Bilbster, Mr C. MacLennan (97); Staxigoe, Mr Geo. Sutherland (97); Tannach, Mr J. T. Robison (97); Thrumster, Mr D. Finlayson (97); Whaligoe, Miss C. Sutherland (97).

COUNTY OF CLACKMANNAN.

Parish of Alloa Town—Alloa Burgh, Mr A. Wilson (51); Ludgate, Mr W. Millar (51); Sunnyside, Mr Ferguson (51); Alloa Epis., Mr M. H. Locker (51); Parish of Alloa (Landward)—Sauchie, Mr J. W. Paterson (51); Parish of Alva—Alva, Infant, Miss M. J. Lodge (51); Parish of Clackmannan—Clackmannan, Mr J. R. Renton (51); Forestmill, Miss Anderson (51); Kennet, Miss M. S. Aitchison (51); Parish of Dollar—Dollar, Mr J. Begg (51); Parish of Tillicoultry—Coalsnaughton, Mr J. Hunter (51); Tillicoultry, Mr J. Wilson (51).

COUNTY OF DUMBARTON.

Parish of Arrochar—Ardlui, Miss Lumsden (101); Arrochar, Mr C. Grierson (101); Parish of Bonhill—Alexandria, Main St, Mr A. F. Campbell (105); Vale of Leven Academy, Mr D. Macintyre (105); Bonhill, Mr A. K. Edward (105); South Jamestown, Mr D. R. Balls (105); Parish of Cardross—Cardross, ? (105); Renton, Mr J. Andren (105); Parish of Cumbernauld—Cumbernauld, Mr D. McPhie (10); Southern District, Miss E. McPhie (10); Burgh of Dumbarton—Academy, Mr A. T. Watson (106); Knoxland, ? (106); West Bridgend, Mr W. D. Anderson (106); Parish of Kilmaronock—Ardoch Bridge, Miss J. Forbes (105); Kilmaronock, Mr Lang (105); Parish of Kirkintilloch—Lenzie Academy, Mr A. Buchanan (12); Townhead, Mr D. Cameron (12); Parish of Kirkintilloch (Landward)—Condorrat, Mr W. Kerr (12); Tweechar, Mr J. Smith (12); Parish of Luss—Luss, Mr A. Forsyth (105); Muirland, Miss J. B. Cunningham (105); Parish of East Kilpatrick—Craigton, Mr D. Lindsay (19); Temple, Mr. J. Scott (19); Parish of West Kilpatrick—Clydebank, ? (22); Duntocher, ? (22); Milton, Mr G. Jennings (22); Parish of Roseneath—Roseneath, Mr W. Stewart (105); Parish of Row—Garelochhead, Mr J. Connor (105); Glenfruin, Miss M. A. Grant (105); Helensburgh, Grant and James St, Mr J. A. Crabbe (105); Helensburgh Hermitage, Mr D. Buchanan (105); Row, Mr W. Fraser (105); Shandon, Miss A. S. Connor (105); Helensburgh, Trinity Episc., Mr A. J. Bailey (105).

COUNTY OF DUMFRIES.

Parish of Annan—Academy, Mr W. Duncan (37); Annan, Mr W. Howe (37); Breconbeds, Mr J. Donaldson (37); Parish of Applegarth and Sibbaldbie—Sandyholm, Mr James Scott (37); Sibbaldbie, Mr G. Nettleship (37); Parish of Brydekirk—Brydekirk, Mr W. Thorburn (37); Parish of Canonbie—Gilnockie, Mr J. Hannam (37); Glenzier, Mr W. Guthrie (37); Harlaw, Mr W. G. Robertson (37); Parish of Caerlaverock—Glencaple, Mr W. Alexander (35); Parish of Closeburn—Closeburn, Miss Somerville (36); Gubhill, Mr Ja. Riddick (36); Wallace Hall Academy, Mr H. F. Menzies (36); Parish of Cummertrees—Trailtrow, Mr Wm. J. Rae (35); Parish of Dalton—Dalton, Mr A. Galbraith (37); Parish of Dornock—Dornock, Mr J. Dunlop (37); Parish of Dryfesdale—Lockerbie Academy, Mr P. Malcolm (37); Burgh of Dumfries—George Street, Mr J. Douglas (35); Loreburn Street, Mr J. B. Waddell (35); St Michael's Street, Mr. J. Hendrie (35); St Andrew's, R. C., Mr J. Burns (35); St John's Episcopal, Mr L. G. MacDonald (35); Parish of Dumfries (Landward)—Brownhall, Mr J. White (35); Catherinefield, Mr D. H. Hutcheon (35); Noblehill, Mr T. Laing (35); Parish of Dunscore—Burnhead, Mr J. Dickson (36); Dunscore Village, Mr D. Gold (36); Parish of Durrisdeer—Birleyhill, Mr J. Connell (36); Durrisdeer, Mr J. R. Boyle (36); Enterkinfoot, Miss Dobson (36); Parish of Eskdalemuir—Davington, Mr E. H. Scott (37); Parish of Ewes—Ewes, Mr J. Lyall (37); Parish of Glencairn—Craigmuie, Miss E. Anderson (36); Moniaive, Mr K. Hunter (36); Parish of Gretna—Gretna, Mr James McIndoe (37); Mount Pleasant, Mr A. S. Farquhar (37); Parish of Hoddam—Hoddam, Mr A. Fairnie (37); Parish of Holywood—Holywood, Mr W. Kennedy (36); Speddoch, Miss Bell (36); Steilston, Mr John Kennedy (36); Parish of Hutton and Corrie—Corrie, Mr T. McLuskie (37); Hutton, Mr J. B. Edgar (37); Parish of Johnstone—Cogrieburn, Mr D. Angus (37); Goodhope, Mr J. Forsyth (37); Johnstone, Mr T. Craig (37); Parish of Keir—Lower, Mr J. R. Gordon (36); Upper, Mr J. B. Soutar (36); Parish of Kirkconnel—Cairn Combination, Mr J. Love (36); Parish of Kirkmahoe—Dalswinton, Mr T. Byers (36); Parish of Kirkmichael—Garrel, Mr R. K. Howie (37); Nethermill, Mr W. Hair (37); Parish of Kirkpatrick Fleming—Gair, Mr W. Turnbull (37); Kirkpatrick Fleming, Mr C. F. Brown (37); Parish of Kirkpatrick Juxta—Dumgree, Mr J. Smith (37); Kirkpatrick Juxta, Mr A. W. Wright (37); Parish of Langholm—Langholm Academy, ? (37); Wauchope, Miss Janet Bell (37); Parish of Lochmaben—Hightae, Mr Jas. McGregor (37); Lochmaben, Mr J. D. Dean (37); Templand, Mr D. Paterson (37); Parish of Middlebie—Hottsbridge, Mr J. Campbell (37); Middlebie, Mr Wm. Kerr (37); Eaglesfield, Mr J. L. Boyle (37); Parish of Moffat—Academy, Mr J. Duncan (37); Annan Water, Mr A. Prosser (37); Evan Water, Mr D. G. C. Stewart (37); Moffat Water, Mr Pollock (37); Parish of Morton—Morton Infant, Miss C. McKay (36); Carronbridge, Duke of Buccleuch's, Mr D. Smart (36); Parish of Mouswald—Mouswald, Mr J. F. Young (35); Parish of Penpont—Penpont, Mr W. Laidlaw (36); Parish of St Mungo—St Mungo, Mr J. Paterson (37); Parish of Sanquhar—Sanquhar, Mr R. N. Carson (36); Mennoch Bridge, Duke of Buccleuch's, Miss K. Simpson (36); Wanlockhead, Mr J. Edmond (36); Parish of Tinwald—Amisfield, Mr F. Ellon (37); Shieldhill, Miss Mundell (37); Parish of Torthorwald—Collin, Mr J. Proudfoot (35); Torthorwald, Mr J. McDougall (35); Parish of Tundergarth—Tundergarth, Mr C. Wilson (37); Parish of Tynron—Tynron, Mr Wm. Gookin (36); Tynron Endowed, Mr J. Lawrie (36); Parish of Westerkirk—Megdale, Mr John Buchan (37); Westerkirk, Mr W. S. Irving (37).

COUNTY OF MIDLOTHIAN.

Parish of Borthwick—Borthwick, Mr J. J. H. Reid (47); Parish of Carrington—Carrington, Mr R. B. Brunton (47); Parish of Cockpen—Bonnyrigg, Mr A. Somerville (47); Cockpen, Miss C. Graham (47); Parish of Colinton—Colinton, Mr A. Robertson (46); Juniper Green—Inf. and Ind., Miss Davidson (46); Juniper Green, Mr Jas. Malloch (46); Slateford, Mr A. Peterson (46); Swanston, Miss Graham (46); Parish of Corstorphine—Corstorphine, Mr G.

McGowan (46); Parish of Cramond—Davidson's Mains, Mr W. Bannerman (46); Lennie, Mr R. B. Finlayson (46); Parish of Cranston—Cousland, Mr J. Simpson (47); Cranston, Mr G. J. D. Barnes (47); Parish of Crichton—Crichton, ? (47); Pathhead, St Mary's R. C., Miss Gibney (47); Parish of Currie—Balerno, ? (47); Currie, Mr J. Jarvie (47); Hermiston, Miss Houston (47); Parish of Dalkeith—King's Park, Mr P. Marshall (47); City of Edinburgh—Bristo, Mr J. Philip (44); Broughton, Mr A. Hutcheson (44); Bruntsfield, Mr J. King (44); Davie Street, Mr J. McCrindle (44); Dean, ? (44); Duddingston, Mr A. Millar (44); Flora Stevenson, Mr D. Gloag (44); Granton, Mr A. Scott (44); Leith Walk, Mr W. Alexander (44); London Street, Mr A. Shennan (44); North Canongate, Mr A. Young (44); North Merchiston, Mr A. H. Taylor (44); Parsons Green, Mr Williamson (44); Portobello, ? (44); Portobello, Tower Bank, Mr R. Todd (44); St Bernard's, Mr W. Mackay (44); South Bridge, ? (44); South Morningside, Mr J. Watson (44); Warrender Park, Mr Jas. Andrew (44); West Fountainbridge, Mr A. J. Johnston (44); Abbeyhill Epis., Miss Mackie (44); All Saints' Epis., Mr H. Hunter (44); Deaf and Dumb Institute, Mr E. Illingworth (44); Practising Epis., Mr W. L. Rayner (44); St Andrew's Epis., Mrs M. E. Morison (44); St James' Epis., ? (44); Parish of Fala and Soutra—Fala and Soutra, Mr J. Duncan (47); Parish of Glencorse—Glencorse, Mr A. G. Bertram (47); Parish of Heriot—Heriot, Mr W. Weir (47); Parish of Inveresk (Landward)—Cowpits, Miss Dunn (46); Craighall, Miss Brown (46); Wallyford, Miss Allan (46); Parish of Kirknewton and East Calder—East Calder, Mr J. Black (47); Kirknewton, Mr T. Dick (47); Oakbank, Mr W. Millar (47); Parish of Lasswade—Lasswade, Mr James Gall (47); Loanhead, Mr R. M. Mackinnon (47); Pentland, Mr T. L. Lee (47); Rosewell, Mr D. Nelson (47); Roslin, Mr E. A. White (47); Loanhead St Margaret's, R. C., Mr M. Macintosh (47); Parish of Leith (Burgh)—Academy, Mr J. W. Tait (45); Bonnington Road, ? (45); Couper Street, Mr W. Darling (45); Great Junction Street, ? (45); Links Place, ? (45); Lochend Road, Mr R. Donaldson (45); Lorne Street, ? (45); Newhaven, Victoria, Mr R. B. Scott (45); North Fort Street, Mr J. Fraser (45); St Thomas, Mr J. Morgan (45); Trinity Academy, Mr T. M. Duncan (45); Yardheads, Mr T. Fraser (45); St James' Epis., Mr W. F. Walker (45); Parish of Liberton—Burdiehouse, Mr R. H. Tait (46); Gilmerton, Mr Montgomery (46); Liberton, Mr Thomas Custon (46); New Craighall, Miss A. M. Comrie (46); Gilmerton, The Anderson Female Industrial, Miss Stewart (46); Parish of Mid-Calder—Bellsquarry, Mr Shields (47); Causewayend, Miss Rutherford (47); Burgh of Musselburgh—Grammar, Mr Hope (46); Fisherrow Burgh, Mr J. W. Stephen (46); St Peter's Epis., Mr Stone (46); Parish of Newbattle—East Houses, Mr M. B. Trail (47); Parish of Penicuik—Howgate, Mr Jas. Downs (47); Kirkhill, ? (47); Penicuik Epis., Miss Annand (47); Parish of Ratho—Ratho, Mr T. Heslop (46); Dalmahoy, St Mary's Epis., Mr Pullan (46); Parish of Stobhill—Stobhill, Mr J. Hastie (47); Parish of Temple—Temple, Miss G. S. Lauder (47); Toxside, Mrs Cook (47); Parish of West Calder—Gavieside, Mr J. H. Taylor (47); Harburn, Miss Anderson (47); Leavenseat, Mr A. McIntosh (47); Woodmuir, Mr J. Graham (47).

COUNTY OF ELGIN.

Parish of Alves—Alves, Mr J. D. Cheyne (89); Parish of Bellie—Bellie, Mr A. J. Adams (88); Fochabers Milne's Institute, ? (88); Parish of Birnie—Birnie, Mr A. Murray (90); Parish of Cromdale—Advie, Mr W. T. Norval (91); Cromdale, Mr James Slater (91); Dava, Miss Jean Peace (91); Parish of Dallas—Kellas, Miss M. Clark (90); Parish of Drainie—Drainie, Mr J. McDonald (88); Lossiemouth, Mr A. S. Melvin (88); Parish of Duffus—Burghead, Mr J. Bremner (89); Duffus, Mr J. W. Corrigal (89); Roseisle, Miss H. Cowper (89); Parish of Dyke—Dyke, Mr J. J. Burgess (89); Kintessack, Miss Russell (89); Parish of Edinkillie—Conicavel, Mr J. McColl (90); Logie, Mr W. Russell (90); Relugas, Miss F. Maclennan (90); Burgh of Elgin—Bishopmill, Mr G. Sutherland (88); Elgin, Girls, Miss Stephen (88); West End, Mr P.

Dow (88); Parish of Elgin (Landward)—Mosstowie, Mr W. Scott (88); New Elgin, Mr J. S. Turner (88); Parish of Kinloss—Findhorn, Mr J. Dewar (89); Kinloss, Mr J. Stewart (89); Parish of Knockando—Elchies, Mr J. Milne (90); Knockando, Mr C. Watt (90); Archiestown, Miss C. M. Turner (90); Parish of New Spynie—New Spynie, Mr J. Thomson (88); Parish of Rafford—Burgie, Miss A. Jeffrey (90); Parish of Rothes—Rothes, Mr T. R. Watson (90); Parish of St Andrews Lhanbryde—Cranloch, Mr W. T. Melvin (88); St Andrews Lhanbryde, Mr R. Stephen (88); Parish of Speymouth—Garmouth, Mr W. F. Stewart (88); Speymouth, Mr A. Geddie (88); Parish of Urquhart—Urquhart, Mr A. Ritchie (88).

COUNTY OF FIFE.

Parish of Abdie—Abdie, Mr A. Lornie (55); Parish of Aberdour—Aberdour, Mr R. Young (53); Donibristle Colliery, Mr P. Williamson (53); Parish of Anstruther Easter—Anstruther Easter, Mr J. Paterson (55); Parish of Anstruther Wester—Anstruther Wester, Mr W. P. Wilson (54); Parish of Auchterderran—Auchterderran, Mr A. Rankine (53); Cardenden, Mr T. A. McEwen (53); Parish of Auchtermuchty—Dunshalt, Miss Melville (57); Parish of Auchtertool—Auchtertool, Mr J. Glendinning (53); Parish of Ballingry—Ballingry, Mr J. Park (57); Parish of Balmerino—Balmerino, Mr T. Barrie (55); Parish of Beath—Cowdenbeath, ? (57); Foulford, Mr W. A. Guthrie (57); Hill of Beath, ? (57); Kelty, Mr James B. Calder (57); Parish of Burntisland—Burntisland Episcopal, Miss J. Stewart (53); Parish of Cameron—Cameron, Mr J. Robertson (55); Denhead, Miss B. McGillivray (55); Radernie, Mr W. Wilson (55); Parish of Carnbee—Arncroach, Mr J. Donaldson (55); Carnbee, Mr J. Pentland Smith (55); Parish of Carnock—Cairney Hill, Mr J. B. Rankine (52); Parish of Collessie—Collessie, Mr W. Penman (57); Ladybank, Mr T. H. Ross (57); Parish of Crail—Crail, Mr M. Ireland (55); Parish of Culross—Geddes, Mr J. Ramsay (52); Parish of Cults—Cults, Mr G. L. Leitch (55); Parish of Cupar (Landward)—Brighton, Miss J. C. Cumming (55); Parish of Dairsie—Dairsie, Mr W. S. Seath (55); Parish of Dalgety—Hillend, Mr J. Forrester (53); Parish of Dunbog—Dunbog, Mr J. Anderson (55); Parish of Dunfermline (Burgh)—McLean, Mr C. McChlery (52); Milesmark, Mr W. Hepburn (52); Queen Anne, ? (52); St Leonards, ? (52); Parish of Dunfermline (Landward)—Charlestown, Mr J. Davidson (52); Crossford, Mr A. Borthwick (52); Crossgates, Mr R. Wallace (52); Halbeath, Mr J. Robertson (52); Limekilns, Mr A. Todd (52); Townhill, Mr J. Marshall (52); Wellwood, Mr G. Henderson (52); Parish of Dunino—Dunino, Mr J. W. Somers (55); Parish of Dysart (Burgh)—Dysart, Mr John Boyd (54); Parish of Elie—Elie, Mr R. Crombie (55); Parish of Falkland—Falkland, Mr J. Richardson (57); Freuchie, Mr J. Methven (57); Parish of Flisk—Flisk, Mr D. M. Dingwall (55); Parish of Forgan—Forgan, Mr J. Cameron (55); Wormit, Mr D. M. Allison (55); Parish of Inverkeithing—Inverkeithing, Mr D. M. Scott (53); North Queensferry, Mr J. M. Cuthill (53); Parish of Kennoway—Kennoway, Mr James Blair (54); Star, Mr W. McLachlan (54); Parish of Kettle—Kettle, Miss Lawson (57); Parish of Kilconquhar—Colinsburgh, Mr J. H. Balleny (55); Kilconquhar, Mr D. L. Pye (55); Parish of Kilmany—Kilmany, Female, Miss White (55); Parish of Kilrenny—Cellardyke, Mr J. Barbour (55); Kilrenny Upper, Mr R. Forsyth (55); Parish of Kinghorn—Kinghorn, Mr W. Mann (53); Kinghorn, Infant, Miss Gibson (53); Parish of Kinglassie—Kinglassie, Mr W. Spears (54); Parish of Kingsbarns—Kingsbarns, Mr R. McKenzie (55); Parish of Kirkcaldy—Abbotshall, Mr J. Ogilvie (58); East, Mr W. Watson (58); High (Elem. Dept.), Mr J. Corrie (58); Parish of Kirkcaldy and Dysart (Landward)—Chapel, Mr G. Harris (54); Strathore, Mr D. T. Brunton (54); Parish of Largo—Durham, Miss Riach (54); Kirkton, Mr T. Nicholl (54); Lundin Mill, Mr D. M. Stewart (54); Parish of Largoward—New Gilston, Mr J. Inch (55); Parish of Leslie—Leslie, Mr D. McLeod (57); Parish of Leuchars—Balmullo, Mr D. Murrie (55); Guardbridge, Mr R. Anderson (55); Leuchars, Mr J. Cribbes (55); Parish of Lochgelly—Lochgelly, Mr P. MacDuff (53); Lumphinnans, Mr D. Low (53); Parish of Markinch—Balcurvie, Mr A. Coutts (54); Coaltown, Mr A. S. Coutts (54); Markinch, Mr D. G. Coull (54); Preston, Mr James Munro

(54); Parish of Monimail—Easter Fernie, Mr C. Arnott (55); Letham, Mr C. D. Smitton (55); Parish of Moonzie—Moonzie, Mr J. Douglas (55); Parish of Newburgh—Newburgh, Mr John Howat (55); Parish of Newburn—Newburn, Mr F. R. Lumsden (55); Parish of Pittenweem—East, Mr A. Howat (55); South, Miss Watson (55); Parish of St Andrews (Burgh)—Burgh, Mr E. King (55); Parish of St Andrews (Landward)—Boarhills, Mr T. S. Glover (55); Parish of St Monance—St Monance, Mr Isaac Neirn (55); Parish of Scoonie—Smithy Green, Miss Ferrier (54); Parish of Springfield—Springfield, Mr J. Forbes (57); Parish of Strathmiglo—Gateside, Mr Duff (57); Strathmiglo, Mr G. Braid (57); Parish of Wemyss—Wemyss, Dorothy, Mr D. H. Lindsay (54).

COUNTY OF FORFAR.

Parish of Aberlemno—Aberlemno, Mr J. Stewart (73); Pitkennedy, Mr W. Irvine (73); Parish of Airlie—Airlie, Mr W. Lyon (68); Parish of Arbirlot—Arbirlot, Mr Wilson (65); Parish of Auchterhouse—Auchterhouse, Mr J. Robertson (68); Burgh of Arbroath—High (Elem. Dept.), Miss M. Duguid (64); Inverbrothock, Mr A. F. Davidson (64); Keptie, Mr J. Kinnear (64); The Abbey, Mr J. Hunter (64); The Hill, Mr J. Guild (64); Parish of Barry—Barry, Mr D. Bain (65); Carnoustie, Mr D. A. Christie (65); Burgh of Brechin—Bank Street, Mr J. D. Ross (73); The Tenements, Mr R. A. Scott (73); Parish of Brechin (Landward)—Aldbar, Mr A. C. Robertson (73); Little Brechin, Mr C. Richard (73); Arrat, Miss J. H. Westwood (73); Town of Broughty Ferry—Eastern, Mr Wm. Sim (65); Grove Academy, Mr Alex. Hutt (65); Southern, Mr R. Cameron (65); Western, Mr J. Thomson (65); Parish of Careston—Careston, ? (73); Parish of Carmyllie—East, Mr G. S. M^{c}Donald (67); West, Mr W. F. Anderson (67); Parish of Craig—Ferryden, Infant, Miss J. Coull (72); Westerton, Mrs J. Wilkie (72); Parish of Cortachy and Clova—Clova, Mr G. Cameron (75); Glenprosen, Mr R. H. Volume (75); Wateresk, Mr T. Campbell (75); Burgh of Dundee—Ancrum Road, Mr R. Locke (66); Ann Street, Mr J. Gibson (66); Balfour Street, Mr W. Bertie (66); Blackness, Mr J. Malloch (66); Brown Street, Mr C. Sharp (66); Butterburn, Mr J. A. Anderson (66); Cowgate, Mr G. Sword (66); Dudhope, Mr G. Simpson (66); Glebelands, Mr J. Mudie (66); Harris Academy, Mr J. Brebner (66); Hill St, Mr G. Ferguson (66); Lochee, Liff Road, Mr R. W. Thornton (66); do., South Road, Mr A. Dorward (66); Morgan Academy, Mr W. B. Irvine (66); Rosebank, Mr W. Dickson (66); St Andrew's, Mr A. Leighton (66); Tay St, Mr D. Dawson (66); Victoria Road, Mr R. Loggie (66); Wallace Town, Mr J. Watt (66); Lochee Epis., Mr A. Marr (66); St Martin's Epis., Miss Gibb (66); St Paul's Epis., Mr W. Gray (66); Lochee, St Mary's, R. C., Mr R. A. Smith (66); St Patrick's, R. C., Miss M^{c}Erlain (66); Seafield's Works, Half time, Miss Roy (66); Parish of Dundee (Landward)—Drumgeith, Mr J. Keith (66); Parish of Dunnichen—Craichie, Mr H. S. Deas (67); Letham, Mr T. M. Henry (67); Parish of Eassie and Nevay—Eassie and Nevay, Mr A. Mearns (68); Parish of Edzell—Edzell, Mr T. Bennet (75); Waterside, Miss J. Black (75); Parish of Fern—Fern, Mr J. Miller (75); Burgh of Forfar—West, Mr J. Campbell (67); Parish of Forfar (Landward)—Lunanhead, Mr J. Yuille (67); Parish of Fowlis Easter —Fowlis Easter, Mr G. Colston (68); Parish of Glamis—Glen Ogilvy, The Milton, Mr Henderson (67); Parish of Glenisla—Folda, Mr T. D. Lyon (76); Glenisla, Mr R. Thomson (76); Kilry, Mr J. C. Beaton (76); Parish of Guthrie—Guthrie, Mr J. Smith (73); Parish of Inverarity—Inverarity, Mr P. Elder (67); Parish of Inverkeilor—Chapelton, Mr W. Linton (65); Inverkeilor, Mr Chas. Crawford (65); Parish of Kettins—Kettins, Mr D. Macqueen (68); Parish of Kinnell —Kinnell, Mr W. Gouldie (72); Parish of Kinnettles—Kinnettles, Mr G. Marten (67); Parish of Kirkden—Kirkden, Mr Lee (67); Parish of Kirriemuir—Carroch, Mr S. J. Welch (75); Kirriemuir Evening School, Mr G. Kyd (75); Padanarum, Mr D. W. Fairweather (75); Reform St, Mr A. Phyn (75); Roundyhill, Mr T. Hewit (75); Webster's Seminary, Mr A. Menzies (75); Westmuir, Miss F. A. Hood (75); St Mary's Epis., Mr H. E. Peacock (75); Parish of Liff, Benvie, etc.—Liff, Mr A. M^{c}Caskie (68); Muirhead of Liff, Mr J. B. Dorward (68); Parish of Lintrathen —Braes of Coull, Mr J. Cook (76); Lintrathen, Mr W. F. Anderson (76); Parish of Lochlee—

Lochlee, Mr S. Cruickshank (75); Parish of Logie Pert—Craigo, Mr J. Eaton (73); Parish of Lunan—Lunan, Mr Arch^{d}. Wilson (72); Parish of Lundie—Lundie, Mr J. Scott (68); Parish of Mains and Strathmartine—Downfield, Mr W. Eckford (68); Strathmartine, Mr J. M^{c}Ash (68); Parish of Maryton—Maryton, Miss Mary Kelman (72); Parish of Menmuir—Menmuir, Mr R. Grimm (73); Parish of Monifieth—Monifieth, Mr J. H. Meldrum (65); Parish of Monikie—Bankhead, Mr A. Clark (67); Monikie, Mr P. Grant (67); Newbigging, Mr S. S. Low (67); Burgh of Montrose—Academy, Mr A. J. A. Russell (72); Southesk, Mr J. Stobo (72); Parish of Murroes—Murroes, Mr H. A. Forsyth (67); Parish of Navar and Lethnot—Navar and Lethnot, Mr W. Paterson (75); Parish of Newtyle—Newtyle, Mr Morgan (68); Parish of Oathlaw—Oathlaw, Mr M. A. Thomson (75); Parish of Panbride—Muirdrum, Mrs Nicolls (65); Panbride, Mr J. C. Stuart (65); Parish of Rescobie—Rescobie, Mr W. Simpson (73); Parish of St Vigeans and Arbroath (Landward)—Colliston, Mr R. S. Armit (65); St Vigeans, Mr Jas. Cox (65); Parish of Tannadice—Burnside of Inshewan, Mr W. Mortimer (75); Tannadice, Mr J. Henderson (75); Parish of Tealing—Tealing, Mr P. M. M^{c}Kenzie (68).

COUNTY OF HADDINGTON.

Parish of Aberlady—Aberlady, Mr A. M. Jameson (43); Parish of Bolton—Bolton, Mr A. T. Nicol (43); Parish of Dirleton—Kingston, Mr J. Aitchison (43); Dunbar (Burgh)—Dunbar, Mr A. Caurie (43); Parish of Dunbar (Landward)—East Barns, Mr A. M^{c}Callum (43); Parish of Garvald—Garvald, Mr J. Boucher (43); Parish of Gladsmuir—Longniddry, Mr J. G. Allan (43); Samuelston, Mr J. Winton (43); Haddington Burgh—Primary, ? (43); Roman Catholic, Miss English (43); Parish of Innerwick—Innerwick, Mr P. Purdie (43); Parish of Morham—Morham, Mr W. Graham (43); Parish of North Berwick—Halfland Barns, Miss I. O. Brown (43); High (Elementary Department), Mr T. S. Glover (43); North Berwick, Mr G. Tait (43); Parish of Ormiston—Crossroads, Mr Chalmers (43); Ormiston, Mr R. Henderson (43); Parish of Pencaitland—Pencaitland, Mr C. A. Ritchie (43); Parish of Prestonpans—Prestonpans, Mr J. Wallace (43); Parish of Salton—Salton, Mr W. A. Findlay (43); Parish of Spott—Spott, Mr R. Grieve (43); Parish of Stenton—Stenton, Mr J. Brown (43); Parish of Whitekirk and Tyninghame—Tyninghame, Mr R. A. Watt (43); Whitekirk, Mr J. Wood (43); Parish of Whittinghame—Kingside Combination, Miss Hutchison (43); Whittinghame, Mr J. Hunter (43); Parish of Yester—Longyester, Miss E. Muir (43); Yester, ? (43).

COUNTY OF INVERNESS.

Parish of Abernethy and Kincardine—Abernethy, Mr A. Steele (91); Dorback, Miss A. Cruickshank (91); Glenbrown and Glenlochy, Miss H. M^{c}Gregor (91); Tulloch, Mr G. Cumming (91); Parish of Alvie—Alvie, Mr F. Garden (91); Lagganlia, Miss M. M^{c}Lean (91); Lynwilg, Miss M. M^{c}Donald (91); Parish of Arisaig—Glenuig, Miss Mackay (100); Arisaig, R. C., Miss M. J. M^{c}Cartan (100); Parish of Barra—Castlebay, Mr J. Smith (107); Craigston, Mr C. W. Kelsey (107); Northbay, Mr P. Flanagan (107); Parish of Boleskine and Abertarff—Boleskine, Mr Wm. Traill (94); Fort Augustus, Mr J. D. Robertson (94); Knockchoilum, Miss I. Mackintosh (94); Parish of Bracadale—Carbost, Mr G. Barron (99); Glenbrittle, Miss D. M'Crimmon (99); Struan, Mr W. P. Gold (99); Parish of Croy and Dalcross—Clava, Mr J. Moir (89); Croy, Mr J. Wedderspoon (89); Parish of Daviot and Dunlichty—Brin, Mr J. Macrae (91); Daviot, Mr A. M^{c}Lellan (91); Dunmaglass, Miss J. Davidson (91); Farr, Mr J. G. M^{c}Beth (91); Parish of Dores—Aldourie, Mr M. M^{c}Donald (94); Stratherrick, Mr G. R. Wilson (94); Parish of Duirinish—Borraraig, Mr F. Nicolson (99); Borrodale, Mr J. M^{c}Kay (99); Colbost, Mr J. S. Young (99); Edinbain, Mr D. J. Mackenzie (99); Parish of Duthil and Rothiemurchus—Deshar, Mr J. Galbraith (91); Dulnain Bridge, Mr W. Stuart (91); Duthil, Mr J. Macrae (91); Rothiemurchus, Mr W. Dempster (91); Parish of Glenelg—Arnisdale, Miss M. Macdonald (99); Bracara, Miss C. F. Robertson (99); Glasnacardock, Mr T. O'Reilly

(99); Glenelg District, Mr J. McArthur (99); Parish of Glengarry—Aberchalder, Miss Macnab (94); Invergarry, Mr J. P. Graham (100); Glenquoich, Miss Durnie (100); Parish of Harris—Amhuinnsuidh, Mr J. MacLeod (108); Drinishader, Mr D. Mackinnon (108); Finsbay, Mr D. J. McRa (108); Kyles Stocknish, Mr M. Macarthur (108); Manish, Mr W. Cook (108); Scalpa, Mr J. L. Neil (108); Scarp, Mr D. Craig (108); Scarista, Miss M. Paterson (108); Parish of Insh—Insh, Miss E. W. Whyte (91); Inverness (Burgh)—Central, ? (92); Clachnaharry, Mr J. L. Clark (92); Farraline Park, Mr A. Thomson (92); High (Elementary Department), Mr T. Wallace (92); High (Secondary Department), Mr A. McBain (92); Cathedral, Boys, Mr Hy. Stafford (92); Northern Counties Blind Institution, Mr Anderson (92); Parish of Inverness (Landward)—Culduthel, Mr J. McPherson (92); Leachkin, Mr J. Tough (92); Nairnside, Mr Martin (92); Highland Orphanage, Miss C. A. Strachan (92); Parish of Kilmallie—Banavie, Mr J. Young (100); Fort William, Mr A. Mackay (100); Kinlocheil March, Mrs W. Fraser (100); Onich, Mr W. Hay (100); Fort William, R. C., Mr K. Mailley (100); Parish of Kilmonivaig—Roy Bridge, Miss M. Nesbit (100); Tomcharich, Miss R. Cameron (100); Parish of Kilmorack—Beauly, Mr J. Pollock (93); Struy, Mr D. Reid (93); Beauly, R. C., Miss L. McDonell (93); Marydale, R. C., Miss B. Carr (93); Parish of Kilmuir—Kilmaluag, Mr R. S. MacKay (99); Parish of Kiltarlity—Culburnie, Mr H. Henderson (94); Guisachan, Mr J. McPhail (94); Parish of Kingussie—Kingussie, ? (91); Newtonmore, ? (91); Parish of Kirkhill—Kirkton, Miss McGlashan (93); Knockbain, Mr J. Shewan (93); Parish of Laggan—Glentruim, Mr A. Douglas (91); Lochlaggan, Mr J. Livingstone (91); Parish of Moy and Dalarossie—Dalarossie, Mr S. Archibald (91); Moy, Mr J. Hunter (91); Raibeg, Mr D. Cameron (91); Parish of North Uist—Boreray, Mr F. Maclean (107); Claddach Kirkibost, Miss Matheson (107); Glaic, Miss M. McDonald (107); Grimisay, Mr D. Campbell (107); Heisker, Miss M. F. Mackay (107); Locheport, Miss J. M. I. Grant (107); Lochmaddy, Mr J. McDonald (107); Trumisgarry, Mr H. McDougall (107); Parish of Petty—East, Mr J. S. Gloag (89); West, Mr W. McCulloch (89); Parish of Portree—Braes, Mr J. Bruce (99); Glens, Mr R. Ramsay (99); Penefiler, Mr K. Macpherson (99); Portree, Mr A. Gillanders (99); Raasay, Mr H. Macfarlane (99); Rona, Mr A. Murchison (99); Torran, Mr T. Graham (99); Parish of Sleat—Ardvaser, Miss A. McDonald (99); Drumfern, Miss Smith (99); Duisdale, Mr M. Macleod (99); Ferrindonald, Mr J. Christie (99); Kylerhea, Miss M. McKinnon (99); Parish of Small Isles—Eigg, Miss N. Ross (100); Rum, Miss H. O. McCrae (100); Muck, Miss M. A. Campbell (100); Parish of Snizort—Carbost Macdiarmid, Mr J. McIver (99); Kensaleyre, Miss A. Campbell, (99); Parish of South Uist—Balivanich, Miss A. Fyffe (107); Carnan, Miss E. Coulan (107); Eriskay, Mr T. M. Patten (107); Jochdar, Mr Jas. McLaughlin (107); Parish of Stenscholl—Digg, Mr M. A. Mackinnon (99); Staffin, Mr D. J. Macleod (99); Parish of Strath—Breakish, Mr R. J. Stilt (99); Dunan, Mr J. A. MacIntyre (99); Kyleakin, Mr J. D. Gunn (99); Torrin, Miss C. Maclean (99); Parish of Urquhart and Glenmoriston—Bunloit, Miss A. Mackintosh (94); Corrimony, Miss Molly Kane (94); Dalchreichard, Miss M. F. Wilson (94); Glen Urquhart, Mr B. Skinner (94); Invermoriston, Mr W. Grant (94).

COUNTY OF KINCARDINE.

Parish of Arbuthnot—Arbuthnot, Mr A. Mason (74); Parish of Banchory Devenick—Banchory Devenick, Mr R. H. Dean (74); Portlethen, Mr J. R. Hunter (74); Parish of Banchory Ternan—Central, Mr R. H. Paton (79); Crathes, Mr T. Menzies (79); Inchmarlo, Mr W. Gilmour (79); Tilquhillie, Miss A. Morrison (79); Raemoir, Mrs Hadden (79); Parish of Benholm—Benholm, Mr J. Russell (72); Johnshaven, Mr R. Stewart (72); Parish of Bervie—Bervie, Mr T. Mitchell (72); Gourdon, Mr A. Urquhart (72); Gordons, Female, Mrs M. Stewart (72); Parish of Dunnottar—Brackmuirhill, Mr A. Inglis (74); Dunnottar, Mr F. Reid (74); Stonehaven, Epis., Miss L. Rettie (74); Parish of Durris—Crossroads, Mr A. Macdonald (79); Parish of Fettercairn—Fettercairn, Mrs D. J. Young (73); Inch, Mr A. Moodie (73); Fasque, Miss Munro (73); Parish of Fetteresso and Rickarton—Cairnhill, Mr J. Geddes (74); Cookney, Mr C. Innes (74); Muchalls, Miss C. Watson (74); Netherley, Miss Willox (74); Rickarton, Mr J. Faulds (74); Stonehaven, ? (74); Tewel Joint, Miss A. N. Wood (74); Parish of Fordoun—Fordoun, Mr J. G. Wallace (75); Landsend, Mr D. A. Duncan (75); Tipperty, Miss Duncan (75); Parish of Garvock—Garvock, Mr J. Bethune (72); Parish of Glenbervie—Glenbervie, Mr G. H. Kinnear (75); Parish of Kinneff and Catterline—Kinneff, Mr D. G. Dorward (74); Catterline, Miss Cruickshank (74); Parish of Laurencekirk—Laurencekirk, Mr J. Grant (73); Laurencekirk Episcopal, ? (73); Parish of Maryculter—East, Mrs Paton (74); West, Mr W. R. Bain (74); Parish of Marykirk—Marykirk, Mr J. B. Fenton (73); Napier Memorial, Miss M. T. Hampton (73); Parish of Nigg—Cove, Mr A. J. Barclay (74); Kirkhill, Mr G. Tough (74); Parish of St Cyrus—St Cyrus, Mr W. Russell (73); Parish of Strachan—Strachan, Mr J. F. Mackie (79).

COUNTY OF KINROSS.

Parish of Cleish—Cleish, Mr T. Dobbie (57); Parish of Fossoway and Tulliebole—Carnbo, Mr S. T. Lear (57); Fossoway, Mr W. D. Robieson (57); Parish of Kinross—Kinross, Mr J. M. Ross (57); Parish of Orwell—Orwell, Mr A. Duff (57); Milnathort, Reid Memorial, Mr E. Mann (57); Parish of Portmoak—Portmoak, Mr A. Mitchell (57).

COUNTY OF KIRKCUDBRIGHT.

Parish of Anworth—Fleetside, Mr D. Clark (34); Skyreburn, Mr J. Pritchard (34); Parish of Balmaclellan—Endowed Free, Mr J. Mitchell (34); Ironmaccannie, Mr A. M. Murray (34); Monybuie, Miss M. Fleming (34); Parish of Balmaghie—Glenlochar, Mr D. R. Cunningham (34); Laurieston, Mr A. Hitchcock (34); Parish of Bargrennan—Bargrennan, Mr D. K. Barne (34); Knowe, Mr John Lochs (34); Parish of Borgue—Borgue, Mr J. McF. Doig (34); Parish of Buittle—High, Mr Hugh Knox (34); Palnackie, Mr S. McKie (34); Parish of Carsphairn—Carsphairn, Mr J. Wilson (36); Parish of Colvend and Southwick—Barnbarrock, Mr G. Bentham (34); Colvend, Mr James Davidson (34); Southwick, Mr J. C. Ferguson (34); Parish of Corsock—Corsock, Mr Jas. Weir (34); Parish of Crossmichael—Crossmichael, Mr John Clark (34); Parish of Dalry—Corseglass, Miss R. Campbell (36); Dalry, Mr J. Marchbank (36); Stroanfreggan, Mr J. Leny (36); Parish of Girthon—Girthon, Mr Wm. Learmonth (34); Parish of Irongray—Roughtree, Mr M. A. Henderson (36); Parish of Kells—Dee, Miss Smith (34); Kells, Mr James Anderson (34); Mossdale, Mr W. Douglas (34); Pollharrow, Mr Callander (34); Parish of Kelton—Castle Douglas, Mr H. A. Braine (34); Gelston, Mr S. McMurray (34); Rhonehouse, Mr R. Harris (34); Parish of Kirkbean—Kirkbean, Mr W. D. Douglas (34); Preston, Mr W. A. Forsyth (34); Parish of Kirkcudbright—Johnston, Mr J. M. Smith (34); Townhead, Mr A. Matheson (34); Whinnie Liggate, Mr A. McKinney (34); Old Church, Miss Naismith (34); Parish of Kirkgunzeon—Kirkgunzeon, Mr R. Milligan (34); Parish of Kirkmabreck—Kirkmabreck, Mr C. S. Robertson (34); Creetown, St Joseph's R. C., Miss Doran (34); Parish of Kirkpatrick Durham—Kirkpatrick Durham, Mr R. McConachie (34); Parish of Lochrutton—Lochrutton, Mr A. Dick (36); Parish of Minnigaff—Cree Bridge, Mr G. C. Cowburn (33); Parish of New Abbey—Lochend, Mr J. Herries (34); New Abbey, Mr E. McCarrack (34); Parish of Parton—Parton, Mr Jas. Bell (34); Parish of Rerrick—Auchencairn, Mr Geo. A. Mills (34); Dundrennan, Mr J. Scott (34); Parish of Terregles—Terregles, Miss N. A. Black (36); Parish of Tongland—Tongland, Mr Geo. Hunter (34); Parish of Troqueer—Drumsleet, Mr J. Symington (36); Laurieknowe, Mr J. S. Elder (36); Whinnyhill, Miss R. W. McKie (36); Parish of Twynholm—Twynholm, Mr D. G. Taylor (34); Parish of Urr—Dalbeattie, Mr A. Baxter (34); Hardgate, Mr R. Aird (34); Milton, Miss A. J. Robson (34); Springholm, Miss M. McDougall (34); Dalbeattie, R. C., Mrs Hadfield (34).

COUNTY OF LANARK.

Parish of Airdrie (Burgh)—Academy, Mr H. Manners (9); Albert, Mr J. C. Carlisle (9); Chapelside, Mr J. Moffat (9); Rochsolloch, Mr D. M. Simpson (9); Victoria, ? (9); St Margaret's, R. C., Mr J. McGovern (9); Parish of Avondale—Ballgreen, Mr A. Fleming (1); Barnock, Mrs Ramsay (1); Crosshill, Mr J. Millar (1); St Patrick's, R. C., Miss C. Martens (1); Parish of Biggar—High School, Biggar, Mr J. Young (1); Parish of Blantyre—High, Mr D. Dunlop (15); Low, Mr J. Mess (15); Auchinraith, Mr J. Welsh (15); Parish of Bothwell—Bellshill, Mr A. J. Noble (7); Bellshill Academy, Mr J. Donaldson (7); Bothwell, Mr J. M. Crowe (7); Carfin, Mr Thomas Law (7); Carnbroe, Mr J. MacDonald (7); Chapelhall, Mr T. Dymock (7); Hamilton Palace Colliery, Mr G. S. McCallum (7); Mossend, Mr W. R. Archibald (7); New Stevenston, Mr J. Patrick (7); Mossend, R. C., Miss M. Myles (7); Parish of Cadder—Auchinloch, Mr L. Boyd (12); Bishopbriggs, Mr H. Anderson (12); Cadder, Mr T. H. Collier (12); Gartcosh, Mr W. Findlay (12); Lochfauld, Miss M. Smith (12); Stepps Road, Mr A. H. Hunter (12); Parish of Calderhead—Allanton, Mr P. Lorne (8); Calderhead, Mr Heard (8); Dykehead, Mr J. C. Miller (8); Shotts, St Patrick's, R. C., Mr J. B. Daniel (8); Parish of Cambuslang—Hallside, Mr A. Brown (15); Kirkhill, Mr R. Templeton (15); Newton, Mr A. Stevenson (15); Parish of Cambusnethan—Berryhill, Mr R. Dey (4); Cambusnethan, Mr A. Lawrie (4); Overtown, Miss J. Robertson (4); Waterloo, Mr G. R. Dick (4); Wishaw, Mr J. Ingram (4); Newmains, Mr R. Hunter (4); Parish of Carluke—Braidwood, Mr J. Miller (3); Carluke, G. and I., Miss Shollbred (3); Kilncadzow, Mr R. Findlater (3); Market Place, H. G., Mr J. K. Barr (3); Yieldshields, Mr A. Miller (3); Parish of Carmichael—Carmichael, Mr J. Aitken (1); Parish of Carmunnock—Carmunnock, Mr Alexander Rankin (14); Parish of Carnwath—Auchengray, Mr J. M. Cooke (2); Braehead, Mr W. Messer (2); Carnwath, Mr G. C. Murray (2); Forth, Mr M. Yates (2); Haywood, Mr A. McIntosh (2); New Bigging, Miss J. Dunlop (2); Wilsontown, Mr F. P. Wellwood (2); Parish of Carstairs—Carstairs, Mr S. J. Somerville (2); Caledonian Railway Company's, Mr W. A. Russell (2); Parish of Clarkston—Airdriehill, Mr J. McLuckie (9); Drumbreck, Mr J. Millar (9); Longrigg, Mr D. S. Masterton (9); Longriggend, Miss Grant (9); Parish of Covington and Thankerton—Covington, Mr G. Dickson (1); Parish of Crawford—Crawford, Mr J. Murray (1); Daer and Powtrail, Miss C. Dunlop (1); Summit, Mr G. Haddow (1); Parish of Crawfordjohn—Crawfordjohn, Mr J. H. Henderson (1); Whitecleuch, Mr A. Porteous (1); Parish of Culter—Culter, Mr J. Walker (1); Parish of Dalziel—Craigneuk, Mr G. T. Brough (6); Dalziel, Mr W. Fordyce (6); Hamilton Street, Mr D. F. Macmillan (6); High, Mr D. Greig (6); Merry Street, Mr A. Macdonald (6); Milton Street, Mr J. Stalker (6); Muir Street, Mr J. Graham (6); Craigneuk, R. C., ? (6); Motherwell, R. C., Mr G. Bennett (6); Parish of Dolphinton—Dolphinton, Mr C. McKenzie (2); Parish of Douglas—Douglas, Mr C. C. Riach (1); Stablestone, Mr D. McKay (1); Parish of Douglas Water—Douglas Water, Mr E. Waddell (1); Parish of Dunsyre—Dunsyre, Mr J. Miller (2); Parish of East Kilbride—Auldhouse, Mr J. Auld (3); East Kilbride, Mr J. T. Thom (3); Jackton, Mrs J. G. Eaglesome (3); Maxwellton, Mr W. Russell (3); Parish of Glassford—Chapelton, Mr G. Shearer (3); Glassford, Mr T. Laug (3); Parish of Glasgow (Burgh)—Abbotsford, Mr T. C. Anderson (13); Adelphi Terrace, Mr F. W. Grant (13); Alexander's, Mr W. Jamieson (13); Alexandra Parade, Mr John Clanachan (13); Anderston, Mr P. McD. Andrew (13); Annfield, Mr Andrew Hoy (13); Barrowfield, Mr D. Gilchrist (13); Bishop Street, Mr Adam Miller (13); Calton, Mr W. A. Davidson (13); Camlachie, Miss J. Morrison (13); Camden Street, Mr W. Fleming (13); Campbellfield, Mr W. Scott (13); Crookston Street, Mr A. Miller (13); Dalmarnock, Mr W. McIntyre (13); Dennistown, Mr J. Gibson (13); Dobbies Loan, Mr H. Muir (13); Dove Hill, Mr Robert Crawford (13); Dunard Street, Mr J. Wood (13); Finnieston, Mr J. Knox (13); Elmvale, Mr J. Buist (13); Freeland, Mr T. Smith (13); Garnetbank, Mr W. W. Russell (13); Gorbals, Mr Robert Edgar (13); Greenside Street, Mr R. Reid (13); Grove Street, Mr F. Connor (13); Henderson Street, Mr John Middleton (13); Hozier Street, Mr Hugh Cameron (13); Kay, Mr W. S. Jamieson (13);

Kelvinhaugh, Mr W. Lee (13); Kent Road, Mr R. J. Wilson (13); Kent Road H. G., ? (13); Keppochhill, Mr W. Young (13); Martyrs', Mr W. M. Cullen (13); Napiers Hall, Mr J. B. Freebairn (13); Oakbank, Mr J. Whyte (13); Oatlands, Mr J. A. J. Watt (13); Overnewton, Mr David Picken (13); Petershill, Mr John T. Smith (13); Provanside, Mr W. Marshall (13); Queen Mary Street, Mr John Robertson (13); Rose Street, Mr A. L. Smith (13); Rumford Street, Mr John Hay (13); St David's, Mr Hector Dove (13); St George's Road, Mr W. A. Thompson (13); St James', Dr Knight (13); St Rollox, ? (13); Shield's Road, Mr H. McCallum (13); Sir John N. Cuthbertson's, Mr C. S. Ogilvie (13); Springbank, Mr R. Gilfillan (13); Springburn, Mr Jos. Routledge (13); Springfield, Mr J. Brown (13); Townhead, Mr Thos. Lindsay (13); Washington Street, Mr J. Glen (13); Well Park, Mr G. Stewart (13); Willowbank, Mr R. Edgar (13); Wolseley Street, Mr J. D. Robertson (13); Buchanan Institution, Mr A. McLaren (13); Normal Practising, Mr J. Beveridge (13); Our Lady and St Francis, R. C., ? (13); St Joseph's, R. C., Mr W. Lornax (13); St Mary's Epis., Mr G. Harrison (13); Parish of Govan—Bellahouston Academy, Mr D. McGillivray (13); Broomloan Road, Mr J. A. McIntosh (13); Dowanhill, ? (13); Fairfield, Mr B. Hutchison (13); Govanhill, ? (13); Greenfield, Mr A. McLeod (13); Harmony Row, Mr Joseph Scott (13); Kinning Park, Mr T. Brodie (13); Partick, Church Street, Mr Purdie (13); Partick, Hamilton Crescent H. G., Mr S. Fraser (13); Partick, Rosevale Street, Mr D. Taylor (13); Partick, Stewartville, Mr J. Main (13); Partick, Thornwood, Mr W. C. Lindsay (13); Pollokshields, Albert Road, Mr G. S. Brown (13); Polmadie, Mr W. Drummond (13); Rutland Crescent, ? (13); Whiteinch, Mr W. Greenhorn (13); St Saviour's, R. C., Mr T. O'Connor (13); Parish of Hamilton (Burgh)—Academy, Mr D. MacLeod (5); Elementary, Miss Baird (5); Beckford Street, Mr M. Blair (5); Bent Road, Mr W. Hamilton (5); Townhead, Mr J. McCabe (5); St John's Grammar, Mr J. Hendrie (5); Parish of Hamilton (Landward)—Beechfield, Miss Smith (5); Ferniegair, Mr J. Dunn (5); Glenlee, Mr R. Steele (5); Greenfield, Mr J. Blyth (5); Low Waters, Mr R. Muir (5); Quarter, Miss Marshall (5); Cadzow, Mr P. McGall (5); Parish of Lanark (Burgh)—Burgh, Mr A. Johnstone (2); Grammar, Mr H. Henderson (2); Parish of Lanark (Landward)—Nemphlar, Miss J. Millar (2); New Lanark, Mr J. McLatchie (2); Smyllum, R. C., Sisters of Charity (2); Smyllum Blind and Deaf Mutes, Sisters of Charity (2); Parish of Larkhall—Academy, Mr C. W. Thomson (3); Duke Street, Mr James Frame (3); Glengowan, Mr J. Paterson (3); Muir Street, Mr J. A. Beattie (3); Parish of Lesmahagow—Auchinheath, Mr J. L. Tait (1); Bellfield, Mr J. Weir (1); Blackwood, Mr William Martin (1); Kirkfield Bank, Mr J. Dunlop (1); Lesmahagow Senior, Mr M. Glover (1); Lesmahagow Junior, Miss Grierson (1); Waterside, Mr R. Gibson (1); Parish of Libberton—Libberton, Mr W. B. Smellie (2); Parish of Maryhill—Gairbraid, Mr J. Simpson (13); North Kelvinside, Mr D. M. Cowan (13); East Park, Mr Ross (13); Possil Park, ? (13); Parish of New Monkland—Avonhead, ? (10); Gain, Mr J. Kiddie (10); Greengairs, Mr J. Arthur (10); New Monkland, Mr T. Philip (10); Riggend, Mr J. Roger (10); Roughrigg, Mr J. Gorman (10); Parish of Old Monkland—Baillieston, Mr R. Hunter (11); Blairhill, Mr J. Pickin (11); Calderbank, Mr J. Russell (11); Coatbridge H. G., Mr W. Service (11); Coatbridge, Langloan, Mr H. B. Sergeant (11); Mount Vernon, Mr R. Young (11); Old Monkland, Mr J. Laurence (11); West Maryston, Mr J. Gibson (11); Whifflet, Mr Charles B. Noble (11); Coatbridge St Patrick's, R. C., Mr J. Bonner (11); Whifflet, R. C., Mr J. Casey (11); Parish of Pettinain—Pettinain, Mr E. Anderson (2); Parish of Rutherglen (Burgh and Landward)—Burgh, Mr Henry C. Jack (14); Eastfield, Mr W. Forsyth (14); Farie Street, Mr J. F. Scott (14); MacDonald's, Mr George Kerr (14); Parish of Shettleston—Millerston, Mr W. Thomson (11); Shettleston, Mr McHaffie (11); Tollcross, Mr J. Mair (11); Parish of Shotts—Northrigg, Miss S. McLeod (8); Shotts, Mr A. Paterson (8); Parish of Springburn—Wellfield, Mr J. Brown (12); Parish of Stonehouse—Greenside, Infant, Miss E. Black (3); Sandford, Miss Sutherland (3); Townhead, Mr A. McIntosh (3); Parish of Wandell and Lamington—Lamington, Mr D. S. Melville (1); Lamington, Female and Infant, Miss H. H. Allan (1); Parish of Wiston and Roberton—Roberton, Mr J. Waddell (1).

COUNTY OF LINLITHGOW.

Parish of Abercorn—Abercorn, Mr A. Hardie (48); Abercorn, Girls, Miss M. Wilson (48); Parish of Bathgate (Town)—Bathgate, Mr J. H. Wheclaw (49); Bathgate Academy, Mr H. Dunn (49); Parish of Bathgate (Landward)—Starlaw, Miss Wardrop (49); Parish of Bo'ness and Carriden—Bo'ness, Mr J. Dunlop (48); Bo'ness Anderson Academy, Mr W. Gladstone (48); Bo'ness, Infant, Miss A. Brown (48); Borrowstown, Mr Jas. Boyd (48); Carriden, Mr Wm. Andrew (48); Grangepans, Mr E. Nelson (48); Kinneil, Mr J. Hunter (48); Blackness, Miss B. Morrison (48); Bo'ness St Mary's, R. C., ? (48); Parish of Dalmeny—Dalmeny, Mr J. W. Sinton (48); Parish of Ecclesmachan—Craigbinning, Mr J. B. Inglis (48); Parish of Kirkliston—Kirkliston, Mr Jas. Brown (48); Newhouses, Miss McKnight (48); Winchburgh, Mr W. Fowler (48); Parish of Linlithgow—Linlithgow Academy, Mr J. Beveridge (48); Linlithgow, Mr Jas. Forbes (48); Parish of Livingstone—Blackburn, Mr W. Stewart (48); Livingstone, Mr J. Robertson (48); Seafield, Mr M. Gray (48); Parish of Torphichen—Blackridge, Mr R. M. Brown (49); Torphichen, Mr Menzies (49); Parish of Uphall—Broxburn, Mr J. P. Cleghorn (48); Uphall, Mr J. S. Calder (48); Hatton, Infant, Miss Kinnear (48); Parish of Whitburn—East Benhar, Mr R. Macdonald (49); Longridge, Mr T. Sutherland (49); Stoneyburn, Mr J. Steele (49); Whitburn, Mr W. Thomson (49).

COUNTY OF NAIRN.

Parish of Ardclach—Campbell's, Mr D. Fraser (90); Fornighty, Miss E. D. Hall (90); Parish of Auldearn—Auldearn, Mr T. H. Rutherford (89); Moyness, Miss E. J. Garden (89); Parish of Cawdor—Barivan, Miss A. Aird (89); Cawdor, Mrs A. Allen (89); Clunas, Miss Barbour (89); Burgh of Nairn—Monitory, Mr R. Jamieson (89); Parish of Nairn (Landward)—Delnies, Miss J. Penny (89); Geddes, Mr J. Aird (89).

COUNTY OF ORKNEY.

Parish of Cross and Burness—Burness, Mr J. M. Gunn (109); Cross, Miss M. J. Stout (109); North Ronaldshay, Mr C. B. Robertson (109); Parish of Eday—South, Mr J. Carrell (109); Parish of Evie and Rendall—Gairsay, Miss J. D. McEwan (109); Rendall, Mr W. Wylie (109); Parish of Firth and Stennis—Firth, Mr W. Mackay (109); Stennis, Mr F. S. Scott (109); Parish of Harray and Birsay—Birsay, Mr Geo. S. Duthie (109); Harray, Mr P. McCullie (109); Hundland, Mrs Maxullie (109); Parish of Holm—East, Miss E. Sheridan (109); West, Mr J. Inkster (109); Parish of Hoy and Graemsay—Graemsay, Mrs M. S. Campbell (109); Hoy, Mr Rendall, (109); Rackwick, Miss M. T. Moat (109); Burgh of Kirkwall—Kirkwall, Mr J. McEwen (109); Parish of Kirkwall (Landward) and St Ola—Scalpa, Miss J. S. Scott (109); Parish of Lady—Lady, Central, Mr J. Gariock (109); Sellibister, Mr R. Clelland (109); Parish of Orphir—Kirbister, Mr J. Omond (109): Orphir, Mr P. L. Muir (109); Parish of Rousay and Egilshay—Egilshay, Mr W. M. Glen (109); Frotoft, Miss B. Norquay (109); Sourin, Miss J. Marwick (109); Veira, Miss McKenzie (109); Wasbister, Miss M. W. Wards (109); Parish of St Andrews and Deerness—Deerness, Mr M. Spence (109); Tonkerness, Mr S. Thompson (109); Parish of Sandwick—North, Mr J. S. Robertson (109); Yesnaby, Miss M. Spence (109); Parish of Shapinsay—Shapinsay, Mr J. Craigie (109); do. North, Miss J. R. Hamilton (109); Parish of South Ronaldshay and Burray—Burray, Mr A. McCallum (109); Hope, Mr G. Barclay (109); Tomisons, Mr Cruickshank (109); Widewall, Mr D. McCormack (109); Parish of Stromness—Kirbuster, Mr H. R. T. Miller (109); Stromness, Mr D. Hepburn (109); Parish of Stronsay—Central, Mr R. T. Annand (109); North, Female and Infant, Mrs M. L. Tolmie (109); South, Fem., Miss M. Calder (109); Parish of Walls and Flotta—Brims, Miss M. C. Johnston (109); Flotta, Mr A. Forbes (109); North Walls, Miss J. Sinclair (109); South Walls, Mr J. A. Davidson (109); Parish of Westray and Papa Westray—East Side (Skelwick), Miss J. M. Shurie (109); Papa Westray, Miss McConachie (109); Pierowall, Mr J. S. Sutherland (109); West Side (Midbea), H. Stevenson (109).

COUNTY OF SHETLAND.

Parish of Bressay—Bressay, Mr W. G. A. Morgan (110); Parish of Delting—Brae, Mr J. H. Moodie (110); Gonfirth, Miss A. C. McPherson (110); Mid Lee, Mr T. Hanton (110); Olnafirth, Mr D. Fraser (110); Roe, Mr A. Falconer (110); Parish of Dunrossness—Boddam, Miss Morrison (110); Fairisle, Mr D. McLean (110); Quendale, Mr M. R. Johnstone (110); Virkie, Mr H. H. Gear (110); Parish of Fetlar—Fetlar, Mr B. Alexander (110); Parish of Lerwick—Gulberwick, Miss I. Innes (110); Lerwick, Central, Mr W. M. Wightman (110); Anderson Educational Institute, Miss Morrison (110); Quarff, Miss M. J. Henderson (110); Parish of Nesting, Lunnasting, Whalsay and Skerries—Laxfirth, Miss C. Hutchison (110); Lunnasting, Mr A. G. McMichen (110); Whalsay (Borough), Mr H. White (110); Skerries, Mr Geo. Mackay (110); Parish of Northmavine—Eshaness, Miss E. McNicoll (110); North Roe, Mr R. S. Bremner (110); Sullom, Miss M. Calderwood (110); Urafirth, Miss J. Nicolson (110); Parish of Sandsting and Aithsting—Gruting, Mr J. S. Peterson (110); Skeld, Mr H. Mackay (110); West Burrafirth, Mr H. Arthur (110); Parish of Tingwall, Whiteness and Weisdale—Girlsta, Miss J. A. Jamieson (110); Scalloway, Mr W. Robertson (110); Trondra, Miss L. Inkster (110); Weisdale, Mr E. M. Henderson (110); Parish of Unst—Baltasound, Mr D. J. Henderson (110); Haroldswick, Miss M. A. Stephen (110); Uyasound, Miss M. A. Harrison (110); Westing, Mr J. Gifford (110); Parish of Walls, Sandness, Papa and Foula—Dale, Mr J. D. Robertson (110); Foula, Mr P. Henderson (110); Happyhansel, Mr J. Dalziel (110); Parish of Yell—Burravoe, Mr H. Robb (110); Gutcher, Mrs Hoseason (110); Ulsta, Miss M. A. Esson (110); West Yell, Mr J. H. Smith (110).

COUNTY OF PEEBLES.

Parish of Drumelzier—Drumelzier, Mr W. T. C. McIntosh (41); Parish of Innerleithen—Innerleithen, Mr T. Weir (41); Leithenhope, Miss Smith (41); Walkerburn, Mr George Hardie (41); Parish of Kilbucho, Broughton, and Glenholm—Broughton, Central, Mr Hogg (41); Glenholm, Miss Hall (41); Parish of Newlands—Lamancha, Mr W. Kyle (41); Newlands, Mr W. Mackie (41); Parish of Peebles—Peebles, Mr James Tod (41); Halyrude, Miss Murray (41); Parish of Stobo—Stobo, Mr A. Jervies (41); Parish of Traquair—Traquair, Mr A. Menzies (41); Kirkburn, Miss M. T. Fraser (41); The Glen, Miss Dewar (41); Parish of Tweedsmuir—Tweedsmuir, Mr J. Yellowlees (41); Parish of West Linton—West Linton, Mr J. Halley (41); West Linton Episcopal, Miss Lyrie (41).

COUNTY OF PERTH.

Parish of Abernethy—Abernethy, Mr A. Davidson (58); Parish of Abernyte—Abernyte, Mr J. F. Falconer (68); Parish of Alyth—Alyth, Mr D. B. Lawson (70); Gauldswell, Miss E. Fraser (70); Parish of Amulree—Amulree, Mr M. Black (71); Shian, Miss Cameron (71); Parish of Ardoch—Braco, Mr T. B. MacOwan (59); Parish of Arngask—Arngask, Mr J. Wilson (58); Parish of Auchterarder—Aberuthven, Mr J. McMath (58); Auchterarder, Mr D. Arkley (58); Parish of Auchtergaven—Auchtergaven, Mr D. Munro (71); Stanley, Mr J. Cameron (71); Parish of Balquhidder—Balquhidder, Mr William Beattie (59); Lochearnhead, Mr D. McDonald (59); Strathyre, Mrs McGechan (59); Parish of Blackford—Blackford, Mr W. McFarlane (59); Gleneagles, Mr R. Guthrie (59); Tullibardine, Mr L. A. Tovani (59); Parish of Blair Atholl—Blair Atholl, Mr A. Kellock (76); Glenerichty, Miss M. C. Macdonald (76); Pittagowan, Miss A. Reid (76); Strathtummel, Miss M. Livingstone (76); Parish of Blairgowrie—Blairgowrie, Mr R. Robb (70); Parish of Blairingone—Blairingone, Mr A. R. Morrice (51): Parish of Callander—Callander, Mr R. Fulton (59); Parish of Caputh—Spittalfield, Mr McMurtrie (71); Wester Caputh, Miss J. F. Smith (71); Meikleour, Mr G. F. Tennant (71); Parish of Cargill—Burreltown, Mr G. Robertson (70); Newbigging, Mr J. S. Halliburton (70); Parish of Clunie—Clunie, Mr J. Young (70); Parish of Collace—Collace, Mr G. H. Dale (70); Parish of Comrie—Comrie, Mr J. Goldie (58); Glenartney, Miss Anderson (58); Glenlednock, Miss Findlay (58); St Fillans, Mr G. Elder (58); Parish of Coupar Angus—Coupar Angus, Mr G. W. F. Strain (68); Parish of Crieff—Crieff, Mr J. H. Brown (58); Monzie, Mr A. G. Graham (58); Taylor's Institution, Mr G. Pollock (58); St Dominic's, R. C., Miss Doherty (58); Parish of Dron—Dron, Mr A. S. Carnegie (58); Parish of Dull—Aberfeldy, Mr A. Grieve (71); Dull, Mr J. E. Adamson (71); Foss, Miss Alice Barr (71); Styx, Miss Mary McDonald (71); Parish of Dunblane and Lecropt—Dunblane, Mr A. Hamilton (59); Lecropt, Miss J. Duff (59); Dunblane, St Mary's Episcopal, Miss Walker (59); Parish of Dunkeld and Dowally—Butterstone, Miss J. Reid (71); Dowally, Mr M. Chalmers (71); Dunkeld, Royal, Mr G. R. Croll (71); Parish of Dunning—Dunning, Mr W. Kerr (58); Parish of Errol—Errol, Mr W. Reid (68); Glendoick, Mr R. Strathdee (68); Errol, Female and Industrial, Miss C. B. Taylor (68); Parish of Findo Gask—Findo Gask, Mr A. Wanless (58); Parish of Forgandenny—Forgandenny, Mr T. Moffat (58); Parish of Forteviot—Forteviot, Mr W. Sprunt (58); Path of Condie, Mr A. Hossack (58); Parish of Fortingall—Fortingall, Mr J. Simpson (71); Parish of Fowlis Wester—Balgowan, Miss M. Barclay (71); Buchanty, Glenaldmond Subscription, Miss Young (71); Parish of Gartmore—Gartmore, Mr Menzies (59); Parish of Glendevon—Glendevon, Mr W. N. Russell (51); Parish of Inchture—Inchture, Mr T. S. Nicolson (68); Parish of Kenmore—Acharn, Mr D. Ewan (71); Ardtalnaig, Miss M. Ross (71); Fearnan, Miss Roberts (71); Kiltyrie, Mr A. Cameron (71); Lawers, Mr W. Davie (71); Parish of Killin—Creanlarich, Mr H. M. Smith (71); Glendochart, Mr R. Paterson (71); Killin, Mr J. Steven (71); Strathfillan, Miss Matthews (71); Parish of Kilmadock—Deanston, Mr K. S. Murray (59); Drumvaich, Miss J. C. Hislop (59); Kilmadock (Doune), Mr N. C. Merrie (59); Parish of Kilspindie—Kilspindie, Mr G. Nish (68); Parish of Kincardine—Blair Drummond, Miss Innes (59); Kincardine, Mr W. Kilgour (59); Thornhill, Mr J. G. Horne (59); Parish of Kinclaven—Kinclaven, Mr J. Foster (70); Parish of Kinfauns—Kinfauns, Mr J. Sprunt (68); Parish of Kinloch-Rannoch—Auchtarsin, Mr D. Campbell (76); Georgetown, Mr P. McLaren (76); Parish of Kinnaird—Kinnaird, Mr J. Fairweather (68); Parish of Kirkmichael—Glenshee, Mr W. Richmond (76); Parish of Lethendy and Kinloch—Kinloch, Mr J. Arnott (70); Parish of Little Dunkeld—Balnaguard, Miss Wilson (71); Drumour, Miss Forbes (71); Murthly and Airntully, Mr W. Sprunt (71); Parish of Logie Almond—Logiealmond, Mr J. Stalker (71); Parish of Logierait—Logierait, Mr J. Kennedy (71); Grandtully, Lady Stewart's, Miss Mitchell (71); Parish of Longforgan—Longforgan, Mr R. Dow (68); Parish of Maderty—Maderty, Mr W. Forbes (58); Parish of Meigle—Meigle, Mr J. Butter (68); Parish of Methven—Almondbank, Mr J. Paterson (71); Methven, Mr D. M. Carmichael (71); Parish of Moulin—Straloch, Miss A. A. Howe (76); Parish of Muckart—Muckart, Mr D. M. Hall (51); Parish of Muthill—Drummond Street, Mr T. A. Donald (58); Parish of Persie—Blackwater, Mr W. M. Smith (70); Strone of Callie, Mr A. Croll (70); Drimmie Burn, Miss J. J. Grant (70); Parish of Perth (Burgh)—Caledonian Road, Mr D. S. Lowson (69); Central District, Mr W. Paterson (69); Craigie (Western District), Mr W. Barclay (69); Kinnoull, ? (69); Northern District (Balhousie), Mr D. Walker (69); Southern District, Mr J. Clacher (69); St Ninian's Episcopal, Miss Keith (69); Sharp's Institution, ? (69); Parish of Perth, East (Landward)—Craigend, Miss J. Adamson (69); Tulloch, Miss J. E. Scott (69); Parish of Port of Monteith—Dykehead, Mr S. Lardner (59); Port of Monteith, Mr E. Maclean (59); Parish of Redgorton—Redgorton, Mr W. K. Anderson (70); Parish of Rhynd—Rhynd, Mr J. West (58); Parish of St Martin's—Guildtown, Mr J. Meldrum (70); Parish of Scone—New Scone, Mr D. Sutherland (70); Stormontfield, Miss J. D. Jamie (70); Parish of Tenandry—Aldgirnaig, Mr T. McGlashan (76); Glenfincastle, Mr E. M. McLean (76); Parish of Tibbermore—Tibbermore, Mr R. H. Meldrum (70); Parish of Trinity Gask—Trinity Gask, Mr A. Murray (58); Parish of Trossachs—Trossachs, Mr A. C. Macdonald (59); Parish of Weem—Weem Central, Mr J. P. McAlpine (71).

COUNTY OF RENFREW.

Parish of Cathcart—Cathcart, Mr A. Wylie (14); Crossmyloof, ? (14); Queen's Park, ? (14); Busby St Joseph's, R. C., Miss A. Rattray (14); Parish of Eastwood—Pollokshaws, Sir J. Maxwell's, Mr J. Prentice (16); Shawlands Academy, Mr Macnab (16); Thornliebank, Mr J. S. Conner (16); Parish of Erskine—Erskine, Mr J. M. Duncan (21); Undercraig, Mr J. M. Wilkie (21); Parish of Greenock (Burgh)—Ardgowan, Mr A. Bremner (24); Belville Place, Mr M. Carmichael (24); Glebe, Mr John Wilson (24); Highlanders Academy, Mr R. Wilson (24); Hillend, Mr James Watson (24); Holmscroft, Mr William Cook (24); Mearns Street, Mr Andrew Young (24); St Andrews Square, Mr A. K. Macdonald (24); Shaw Street, Mr W. B. Ingram (24); West St John's Episcopal, Mr E. Murray (24); Parish of Greenock East (Landward) and Port Glasgow (Landward)—Ladyburn, Mr W. Lees (21); Parish of Houston and Killellan—Houston, Mr A. More (17); St Fillan's, R. C., ? (17); Parish of Inverkip—Inverkip, Mr J. Lang (23); Parish of Kilbarchan—Kilbarchan, Mr M. Mycroft (17); Linwood, Mr J. Macfie (17); Parish of Kilmalcolm—Kilmalcolm, Mr W. L. Walker (21); Parish of Levern—Levern, Mr J. Wood (16); Parish of Lochwinnoch—Glenhead, Mr M. P. Holmes (17); Howwood, Mr J. Thomson (17); Lochwinnoch, Mr J. Millar (17); Parish of Mearns—Busby, Mr T. Russell (16); Mearns, Mr J. S. Downie (16); Parish of Neilston—Barrhead, Mr A. Rodger (17); Grahamston, Mr H. R. Dalziel (17); Neilston, Mr Doak (17); Uplawmuir, Mr D. G. Nicolson (17); St Thomas, R. C., Miss J. Whyte (17); Parish of Paisley (Burgh)—Ferguslie, Mr R. Ferguson (18); North, Mr A. Fairlie (18); South, Mr W. Taylor (18); South, Infant Dept., Miss McNair and Miss McAndrew (18); West, Mr G. Dick (18); Oakshaw, Mr D. Smith (18); Neilson Educational Inst., Mr J. G. Thomson (18); Parish of Paisley (Landward)—Cardonald, Mr J. Wallace (20); Inkerman, Mr A. Brown (20); Nethercraigs, Mr J. Cochran (20); Parish of Port Glasgow (Burgh)—Chapelton, Mr M. A. R. Munro (21); Clune Park, Mr D. Dryborough (21); Parish of Renfrew (Landward)—Oswald, Mr R. McKechnie (19); Scotstown, Mr J. McKean (19); Yoker, Mr J. Barr (19).

COUNTY OF ROSS AND CROMARTY.

Parish of Alness—Boath, Miss P. Cumming (93); Parish of Applecross—Aligin, Mr A. Macphail (99); Applecross, Mr J. D. Matheson (99); Arinacrinachd, Mr D. Mackenzie (99); Dibaig, Mr G. P. MacMartin (99); Shieldaig, Miss H. Mackenzie (99); Torridon, Miss G. Ironside (99); Parish of Avoch—Avoch, Mr D. F. Fleming (93); Killen, Mr McDonald (93); Parish of Barvas—Barvas, Mr J. Campbell (108); Bragar, Mr T. S Rennie (108); Lionel, Mr J. McKay (108); Skigersta, Mr M. Maclean (108); Parish of Carnoch—Strathconan, Mr G. Lang (93); Parish of Contin—Scatwell, Mr J. Davidson (93); Parish of Cromarty—Peddieston, Mr W. S. Stevenson (93); Parish of Dingwall—Dingwall Academy—Mr McDonald (93); Parish of Fearn—Balmuchy, Mr J. Mackintosh (95); Hilton, Mr J. Watt (95); Parish of Fodderty—Fodderty, Mr J. McC. Duthie (93); Maryburgh, Mr D. Mackay (93); Parish of Gairloch—Achtercairn, Mr G. H. T. Milne (99); Bualnaluib, Mr R. C. G. Rose (99); Inverasdale, Mr A. Polson (99); Kinlochewe, Miss M. M. Band (99); Laide, Miss B. Summers (99); Mellon Udrigle, Mr J. M. Summers (99); Melvaig, Mr J. McLennan (99); Pool ewe, Miss M. Campbell (99); Sand, Mrs Calder (99); Parish of Glenshiel—Letterfearn, Mr T. Purdie (99); Shiel, Miss J. A. Maclean (99); Parish of Killearnan,—Killearnan, Mr W. McIntosh (93); Tore, Miss H. Macdonald (93); Parish of Kilmuir Easter—Kilmuir Easter, Mr T. G. Meldrum (95); Tullich, Miss J. Mackenzie (95); Parish of Kincardine,—Achnahannet, Mr J. A. Fotheringham (96); Loubcroy, Miss Lily Banks (96); Gledfield, Mr G. G. Macleod (96); Parish of Kinloch Luichart—Kinloch Luichart, Mr D. Macrae (93); Strathgarve, Miss Cram (93); Achnasheen, Mr D. Duff (99); Parish of Knockbain—Munlochy, Mr W. Harvey (93); Upper Knockbain, Mr J. Forbes (93); Arpafeelie, St John's Epis., Mr J. A. Clement (93); Parish of Lochalsh—Auchmore, Miss J. Mackay (99); Lochalsh, Mr D. Macrae (99); Plockton, Mr J. Sorley (99); Parish of

Lochbroom—Achiltibuie, Mr D. Urquhart (99); Altando, Mr M. Gray (99); Ardindrean, Mr W. Mackenzie (99); Auchduart, Mr K. McLeod (99); Badcaul, Mr J. Haggarty (99); Lochbroom, Miss Lang (99); Scoraig, Miss M. A. Rae (99); Strathcannaird, Miss C. Mackenzie (99); Tanera, Mr K. McLeod (99); Ullapool, Mr J. Cameron (99); Parish of Lochcarron—Attadale, Miss A. McLeish (99); Balnacra, Mr M. Ross (99); Craig, Miss H. Butter (99); Strome, Mr T. Fowler (99); Parish of Lochs—Achmore, Mr M. McKenzie (108); Airidhbhruaich, Miss A. McLeod (108); Balallan, Mr P. Clemenson (108); Cromore, Mr Given (108); Fidigary, Mr A. G. Burns (108); Graver, Mr J. Maciver (108); Grimshader, Miss A. Martin (108); Kershader, Mr J. Blyth (108); Knock-ian-due, Mr R. Paterson (108); Lurebost, Mr D. Gunn (108); Planasker, Mr W. Kerr (108); Parish of Logie Easter—Scotsburn, Mr R. H. Bone (95); Parish of Nigg—Nigg, Mr A. Urquhart (93); Pitcalnie, Mr C. Campbell (93); Parish of Resolis—Cullicudden, Mr K. Kemp (93); Newhall, Mr F. R. S. Black (93); Parish of Rosemarkie—Fortrose Academy, Mr C. Laverie (93); Rosemarkie, ? (93); Parish of Rosskeen—Invergordon, Mr W. D. Kennedy (95); Strathrusdale, Miss W. C. Ritchie (95); Parish of Stornoway—Laxdale, Mr D. Clark (108); Nicolson, Mr W. J. Gibson (108), Tolsta; Mr J. Gowans (108); Tong, Mr S. Murray (108); Parish of Tain—Inver, Miss M. S. KcKenzie (95); Tain, Mr D. Murray (95); Parish of Tarbat—Old, Mr J. Ewing (95); West, Mr Geo. Ross (95); Parish of Uig—Bernera, Mr J. N. Macleod (108); Breasclet, Mr J. Smith (108); Carloway, Mr R. MacDonald (108); Crowlista, Mr A. H. Stapley (108); Crulivig, Miss A. Macdonald (108); Dun Carloway, Mr F. Smith (108); Isilvig, Mr Macdonald (108); Parish of Urquhart and Logiewester—Conon, Mr W. McLennan (93); Culbokie, Mr W. Fowler (93); Ferintosh, Mr W. Campbell (93); Mulbuie, Mr T. McKenzie (93); Parish of Urray—Marybank, Mr A. J. Forbes (93); Tarradale, Mr K. McLean (93).

COUNTY OF ROXBURGH.

Parish of Ancrum—Ancrum, Mr A. Kennedy (39); Sandystones, Mr T. Mainland (39); Parish of Bedrule—Bedrule, Mr R. W. Ritchie (39); Parish of Bowden—Bowden, Mr J. B. Glen (39); Midlem, Miss Kennedy (39); Parish of Castleton—Riccarton, Miss H. Cunningham (37); Parish of Cavers and Kirkton—Cogsmill, Mr G. M. Skea (38); Denholm, Mr A. Oliver (38); Kirkton, Mr J. Turnbull (38); Parish of Crailing—Crailing, Mr G. Fargie (39); Parish of Eckford—Caverton Mill, Mr W. G. Sanson (39); Parish of Edgerston—Edgerston, Mr Jas. Lawson (39); Parish of Ednam—Ednam, Mr D. Pringle (39); Hawick (Burgh)—Buccleuch, Mr W. Pitcairn (38); Drumlanrigg, Mr J. Fower (38); St Mary's Infant, Miss Barnett (38); Roman Catholic, Miss Butter (38); St Cuthbert's Episcopal, Mr D. Gillis (38); Parish of Hawick (Landward)—Clarilaw, Mr D. McConnachie (38); Dean, Mr A. Turnbull (38); Newmill, Mr W. Robb (38); Stouslie, Mrs Watt (38); Parish of Hobkirk—Hobkirk, Mr J. Culbertson (39); Jedburgh (Burgh)—Grammar, Mr J. M. Archibald (39); St John's Episcopal, Mr A. Sutcliffe (39); Parish of Jedburgh (Landward)—Lanton, Mr A. Pringle (39); Pleasants, Mr T. Clark (39); Parish of Kelso—Kelso, Mr A. B. Fisher (39); Parish of Lilliesleaf—Lilliesleaf, Mr A. Birrell (39); Parish of Linton—Linton, Mr J. Cook (39); Parish of Makerstoun—Makerstoun, Mr Galloway (39); Parish of Maxton—Maxton, Mr T. Boyd (39); Parish of Melrose—Blainslie, Mr A. Bennet (39); Gattonside, Miss Bella Dodd (39); Langshaw, Miss Sanderson (39); Melrose, Mr T. Ingram (39); Newstead, Mr J. C. Bowers (39); Newton St Boswells, Mr J. Roberton (39); Parish of Minto—Minto, Mr A. Harvey (39); Parish of Morebattle—Morebattle, Mr Jas. Henderson (39); Mowhaugh, Mr M. A. R. Downs (39); Parish of Oxnam—Towford, Miss Ellen Jolly (39); Parish of Roberton—Howpasley, Miss W. Innes (38); Roberton, Mr T. Wilson (38); Parish of Roxburgh—Fairnington, Mr W. Henderson (39); Roxburgh, Mr R. Whiteford (39); Parish of St Boswells—St Boswells, Mr W. McDonald (39); Parish of Smailholm—Smailholm, Mr John Brown (39); Parish of Southdean—Glen Douglas, Miss McIvor (39); Southdean, Mr A. C. Milne (39); Parish of Sprouston—Hadden, Mr E. B. Cuthbert (39); Sprouston, Mr Wm. Black (39); Parish of Teviothead—Teviothead, Mr W. R. Elliot (38); Parish of Yetholm—Yetholm, Mr G. Mather (39).

COUNTY OF SELKIRK.

Parish of Ashkirk—Ashkirk, Mr J. Riddle (38); Parish of Caddonfoot—Caddonfoot, Mr T. Litster (40); Parish of Ettrick—Chapelhope, Miss R. S. Ross (40); Ettrick, Mr A. McLaren (40); Burgh of Galashiels—Glendinning Terrace, Mr A. Thomson (40); Ladhope, Mr T. Crerar (40); Old Town, Mr Beveridge (40); Roxburgh Street, Mr W. Dunlop (40); Galashiels Epis., Mr F. H. Hogarth (40); Parish of Galashiels, Landward—Lindean, Miss M. Moodie (40); Parish of Kirkhope—Kirkhope, Mr J. S. Kerr (40); Redfordgreen, Mr M. W. Anderson (40); Gilmanscleuch, Mr T. Elliot (40); Burgh of Selkirk—Selkirk, Mr B. Waddell (40); Parish of Selkirk (Landward)—Bowhill, Miss S. Gunson (40); Parish of Yarrow—Mountbenger, Miss Brown (40); Yarrow, Mr Jas. Watson (40); Yarrowford, Miss Roper (40).

COUNTY OF STIRLING.

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